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Spawning and Development of Some Hawaiian Marine Gastropods[1]

JENS MATHIAS OSTERGAARD[2]

MANY PERSONS, at various marine biological stations situated throughout the world, have investigated the spawning habits and larval development of marine gastropods. Some of the recorded observations date back to the middle part of the last century or earlier. Various methods have been employed to obtain the materials for study, but always the effort put forth has been well rewarded, for the field is exceedingly rich. It is noteworthy that the study of plankton alone has been able to throw much light on the metamorphosis of the larvae of many species. This is a field of investigation that has an economic as well as an academic value, inasmuch as these minute planktonic larvae make a considerable contribution to the food supply of larger organisms, which in turn may serve as food for fishes that are of direct economic importance to man.

The investigations recorded here are the first to be published from this area of the Pacific. All the studies were done at the Marine Biological Laboratory of the University of Hawaii during the years 1920–1925, since which time nothing has been added. There are several reasons for this delay, the main one being the difficulty of publication. This required, among other things, much painstaking labor by a skilled person to adapt the many illustrations for reproduction.

Many illustrations were required to clarify the text and to enable the reader to compare the corresponding stages of species of the same genus. All the figures were drawn in lead pencil by the author from observation under low power of the compound microscope. A micrometer scale was used so that measurements in fractions of millimeters could be made readily.

All the species investigated were obtained in water not over 3 meters in depth, and most of the egg structures were deposited in the laboratory by isolated animals. When the spawns were obtained from the reefs, or elsewhere, careful checks had been made to ascertain their identity, which in most cases was later verified. No record of any species whose generic position was unknown has been included. Hence, discussion of a considerable number of additional species of the Nudibranchiata, whose systematic position has not yet been fully determined, awaits later publication.

No histological sections of embryos and larvae were made, all notes being from external observations. It will be noted that the ova of the various groups of gastropod mollusks discussed here were of the telolecithal type with holoblastic cleavage, of which the first two divisions were almost always equal, while the third division resulted in some blastomeres of minute size and with a small amount of yolk and other larger ones with much yolk. A trochophore stage of very short duration has been observed in some species, while a long veliger stage seems to be present in all. In no case has a metamorphosis from the veliger larva to the adult form been observed, nor even started, although a record was obtained of 21 days of free-swimming existence.

Included in this publication are the results of the study of the development of 41 species which are placed in 28 genera belonging to

[1]Contribution No. 2, Hawaii Marine Laboratory.

[2]Department of Zoology and Entomology, University of Hawaii. (Retired.) Manuscript received May, 1949.

25 families of 3 orders. A key is furnished to aid in the identification of the spawn.

Material collected and in the author's possession consists of egg structures preserved in formaldehyde and balsam mounts of cleavage stages and veliger shells on slides.

Acknowledgments: The author feels indebted to a number of persons for their aid and encouragement in the present undertaking. Thanks are due Dr. Charles H. Edmondson for his fine cooperation in securing specimens of mollusks from which spawn were obtained. I also wish to thank Mr. Otto Degener for having rendered much assistance in procuring living specimens of opisthobranchiate mollusks. I greatly appreciate Dr Robert W. Hiatt's very helpful suggestions and aid in the preparation of the manuscript. Finally, I am greatly indebted to Florence Lambeth for the painstaking skill with which she adapted the drawings for reproduction.

KEY TO THE SPAWN OF SOME HAWAIIAN MARINE GASTROPODS

1. Egg structure consisting of distinct, attached capsules with parchment-like walls or a continuing filament 2
   Egg structure otherwise, more or less aberrant 23

2 (1) Egg structure capsular with compact parchment-like walls 3
   Egg structure consisting of a continuing filament 5

3 (2) Capsules small, 1.5–4 mm. in length, pale yellow 4
   Capsules large, 8 x 10 mm. to 13 x 15 mm., squarish, flat and baggy, more or less corrugated marginally; attached to rock at basal margin or to one another (*Conus omaria*, p. 90); with elongate slit at distal margin which is closed during incubation. Color pale yellow or pink. . . **Conus**, p. 89.

4 (3) Capsules oblong, rounded or pointed; adhering to one another in compact masses. Egg mass covered by foot of animal during incubation. Color pale yellow. . . **Cypraea**, p. 78.
   Capsules elongate, pointed; attached to substratum . . . . . **Mitra**, p. 86.

5 (2) Egg structure a cylindrical filament 6
   Egg structure a ribbon or band . 15

6 (5) Filament long, thin and tangled 7
   Filament short, thick and not tangled 10

7 (6) Filament from 0.5 mm. to 1 mm. in diameter 8
   Filament about 0.25 mm. in diameter, thread-like, comprising many separate threads forming a bundle spread over 4 square cm. Color pale yellow. **Strombus maculatus**, p. 95.

8 (7) Filament of great length, about 1 mm. in diameter, adhering in a compact mass, attached to underside of rocks and spread over an area of 25 square cm. Color pale yellow when freshly laid, brown when embryos are near hatching. . . . . **Tethys grandis** and **T. bipes**, pp. 98, 99.
   Filament not of great length, occupying an area from 2 to 4 square cm. Color pale yellow. 9

9 (8) Filament compactly tangled and attached to substratum . . . . . **Clava obeliscus**, p. 95.
   Filament loosely looped or tangled and festooned on algae . **Tethys elongata**, p. 100, and **Notarchus striatus**, p. 101.

10 (6) Filament with ova transversely arranged in loops within, and visible to the unaided eye . . 11
   Filament without transversely arranged ova 12

11 (10) Filament large, forming an elliptical loop. Length 18 cm., diameter 4 mm. Color white. . . . **Pleurobranchus** sp., p. 107.
Filament small, forming a circular loop. Length 3 cm., diameter 1 mm. . **Bulla** sp., p. 103.

12 (10) Filament slender and tapering to an acute point at the extremities 13
Filament thick with obtuse or blunt extremities with or without spiral twists 14

13 (12) Filament forming one volution without loops. Length 19 mm., diameter 1 mm. Color white. . . . . **Placobranchus** sp., p. 107.
Filament with a few irregular loops. Length 25 mm., diameter 0.5 mm. Color white. . . . . **Elysia** sp., p. 108.

14 (12) Filament with one or two turns, flatly arranged. Length from 2.5 to 4 cm. Color white. . . . . **Morula dumosa,** p. 96, and **Haminoea crocata,** p. 104.
Filament with three and a half spiral turns, with one end attached to a gelatinous base or to the substratum. Length 35 mm., diameter 3 mm. Color white. . . . . **Bullina scabra solida,** p. 103.

15 (5) Ribbon attached by one edge or by a basal support to substratum 16
Ribbon attached flatly to substratum 22

16 (15) Ribbon a much-folded mass attached by a basal support to substratum about 2.5 cm. in height and 1.5 cm. in width. Color white. . . . . **Hydatina amplustre,** p. 102, and **H. physis,** p. 102.
Ribbon attached by one edge to substratum 17

17 (16) Ribbon very large and intensely folded, forming three or four circularly wound volutions which measure about 13 cm. across. Color pink. . . . . **Umbraculum sinicum,** p. 105.
Ribbon small and with only slight folds or none 18

18 (17) Ribbon rising vertically from margin of attachment 19
Ribbon sloping outward from centrally placed margin of attachment 21

19 (18) Ribbon of one volution; extremely small white band, about 4 mm. in length . . . . . **Glossodoris** sp., p. 109.
Ribbon of 2 to 3 volutions, 2 to 3 cm. across the mass 20

20 (19) Ribbon bright scarlet or deep orange, forming two volutions, about 14 cm. long and 6 mm. wide . . . . . **Hexabranchus** sp., p. 109.
Ribbon bright yellow, forming 3 volutions, about 11 cm. long and 4 mm. wide . . . . . **Cryptodoris** sp., p. 109.

21 (18) Ribbon with one volution. Diameter of entire structure about 1 cm. Color bright yellow. . . **Aeolidia** sp., p. 110.
Ribbon with several irregular volutions, 7 mm. wide. Color white. . . **Melibe pilosa,** p. 111.

22 (15) Ribbon with numerous parallel loops, not overlapping, 0.33 mm. wide. Clear and colorless. . . . . **Dolabrifera olivacea,** p. 100.
Ribbon not looped, forming a half circle, about 3 cm. long, 2 mm. wide. Colorless. . . . . **Siphonaria normalis amara,** p. 111.

23 (1) Egg structure consists of groups of unattached, minute capsules, each containing 1 or 2 ova. The capsules about 0.2 mm. in diameter. . . . . **Littorina pintado,** p. 97.

Egg structure not capsular . . . 24

24 (23) Egg structure a gelatinous mass 25

Egg structure not a gelatinous mass but orbicular or fan-shaped and of great size. Diameter 15 cm., thickness about 2 mm. Ova grouped together in masses of about 50, visible to the unaided eye and arranged in transverse rows of about 50. Color pale yellow. . . **Tonna perdix,** p. 96.

25 (24) Egg mass consisting of a globular, soft, clear gelatinous matrix about 18 mm. in diameter in which about a thousand purple-colored ova are imbedded. . . . . **Atys semistriata,** p. 105.

Egg mass of irregular outline, tough, gelatinous, and pasted flatly to any surface, occupying about 5 square cm. Color lemon yellow. . . . . **Peronia** sp., p. 112.

Order PROSOBRANCHIATA
Family *CYPRAEIDAE*

Genus CYPRAEA

Cypraea carneola Linnaeus

Figs. 1, 2

On June 8, 1921, a large adult specimen of *Cypraea carneola* was found on the Waikiki reef, off the Marine Biological Laboratory of the University of Hawaii. This species is not of common occurrence in wading depths on the Hawaiian reefs.

The specimen was brought to the laboratory and placed in a trough with running water, and the following night it deposited an egg mass on the enameled surface of a pan in which it was placed. The egg mass consisted of about 1,000 egg capsules which were imbedded in a firm gelatinous substance.

The individual egg capsule, or egg case, is about 4 mm. long and is triangular, with its flattened base attached to the substratum or to another egg capsule. From its base the egg capsule curves slightly to a somewhat obtuse point (Fig. 1*a*). Its firm parchment-like walls are pale yellow and contain, in a clear viscid capsular fluid, an average of 500 ova (Fig. 1*b*).

During the first day the animal remained constantly on its eggs, covering the entire mass with its foot; thereafter, probably due to having been removed several times, it left its "nest" voluntarily and stayed away.

Under the compound microscope the cleavage of the zygote was studied, as were the resulting embryos as far as the free-swimming larval stage.

The ovum is about 0.14 mm. in diameter, and a concentration of cytoplasm containing the nucleus appears as a clear area about one-fifth the diameter of the ovum. This in turn is surrounded by a dark area, while somewhat globular yolk granules constitute the bulk of the ovum (Fig. 1*c*).

Upon examination of the contents of one of the egg cases the morning after they were laid, none of the zygotes was found to have started cleavage. The contents of another egg case, however, opened at 4:00 P.M. of the same day, revealed many in the two-cell stage scattered among those which had not started cleavage.

This is a telolecithal egg with holoblastic, or total, cleavage, the first two divisions being equal, the third unequal. The first cleavage is vertical and passes through the animal and vegetal poles of the zygote, dividing it into two blastomeres of equal size. The animal, or formative, pole is clearly discernible by the position of the nuclei, the nucleus of each daughter cell being directly opposite that of the other, and close to the cleavage plane (Fig. 1*d*).

An hour later, at about 5:00 P.M., the second division began to take place; and in the

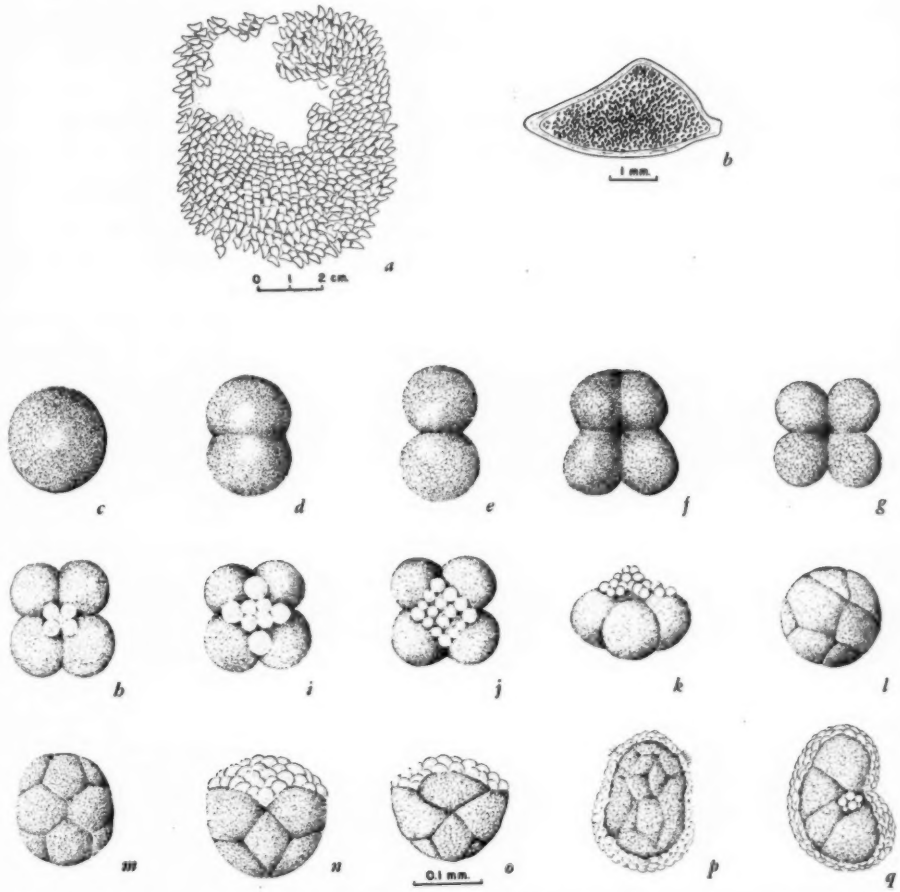

FIG. 1. *Cypraea carneola* Linnaeus. *a*, Egg mass; *b*, capsule enlarged; *c–n*, cleavage stages; *o*, blastula stage; *p*, trochophore stage; *q*, gastrula stage.

course of about ½ hour, nearly all the embryos in the two-cell stage had completely divided into four blastomeres of equal size, symmetrically arranged, and joined together by their inner surfaces. Like the first cleavage, this was vertical and at a right angle to the first. The nuclei of the blastomeres were grouped together about the animal pole. Following each of the preceding cleavages, a contraction and rounding off of the blastomeres occurred which resulted in their being joined at the cleavage planes by a comparatively small area (Fig. 1*g*, *h*).

By 11:00 P.M., another division had taken place in the horizontal plane and at right angle to the two preceding cleavages forming four micromeres and four macromeres (Fig. 1*h*).

At about the same time some embryos had undergone an additional division of the macromeres, thus producing four more micromeres, arranged outside of the others and located in the line of division between the macromeres. The cells of this division were

about twice the volume of the preceding (Fig. 1*i*).

By the following noon, July 10, the micromeres in many of the embryos had increased to 16 in number and, in some instances, they were arranged in orderly rows of four at the animal pole. These cells did not differ much in size; the larger ones were at the outer angles and were, on an average, a little smaller than the first four micromeres. This result had apparently come about through further divisions of the eight micromeres observed in the preceding stage (Fig. 1*j*).

At this time in some of the embryos an additional division of a number of the micromeres had resulted in a crowding together and a piling up into a pointed dome of these small cells at the animal pole (Fig. 1*k*).

At 10:00 P.M., the same day, a marked change had taken place in the appearance of the embryos. An equal division of the macromeres had occurred, making them now eight in number; furthermore, the rounded surfaces of these cells, which had stood out so conspicuously, were now contracted and flattened, giving the whole mass a rather globular form again (Fig. 1*l*, *m*).

Owing to the thickness of the egg capsule, it was not possible to see the minute structures of the embryos without tearing open the capsule and examining the embryos in water. Being thus placed in unnatural environments, their life was usually short and their development retarded. For this reason, the time normally required for the successive steps of development cannot be correctly indicated.

At the time the micromeres became contracted and rounded off peripherally, the micromeres also pulled toward the center, crowded together, and thus, aided by their increased number, helped to restore the embryo to its former globular form. Viewed from the equator the embryo now resembled a basket full of eggs. This stage was observed July 11, at 3:00 P.M. (Fig. 1*n*).

Twenty-four hours later the embryo had become compressed at the poles and had lost its spherical form. In some, 12 macromeres could be seen, a division of the row distal of the vegetal pole having taken place. The micromeres, increasing in number, occupied a larger area of the surface and extended laterally so as to form an obtuse angle with the macromeres. The beginning of movement of the embryo takes place at this stage although cilia cannot yet be seen (Fig. 1*o*).

The following morning, July 13, an elongated form of the embryo had succeeded the former compressed one, the elongation having occurred along the equatorial plane. The micromeres, by their greatly increased number, now extended over almost the whole of the embryo, leaving but a small area of the macromeres uncovered. This was the blastula stage. The body was slightly tapered at the anterior end, where there was a small tuft of short cilia on each side. By means of these cilia the embryo was able to turn over and move backward and forward. This was the trochophore stage (Fig. 1*p*).

Twenty-four hours later, July 14, a gastrula was formed, partly by epiboly and partly by invagination of the macromeres. A constriction near the point corresponding to the vegetal pole of the ovum indicated the position of the blastopore. The micromeres, which were transparent, had become flattened and formed a layer of nearly equal thickness around the macromeres, which appeared as an inner dark mass. The archenteron appeared as a narrow fissure extending through the clear ectodermal layer and into the large yolk-laden endodermal cells. At the inner end of the archenteron, against the endodermal cells, a group of small, clear cells was seen which were probably mesodermal. The length of the embryo at this age was 0.16 mm. (Fig. 1*q*).

An important change took place in the next 24 hours. Two large, ciliated lateral lobes and a smaller median lobe with shorter

cilia developed from the ectoderm at the anterior end of the body. Directly posterior to each lateral lobe there was a clear, rounded protuberance, probably of ectodermal origin. The foot, also developed from the ectoderm, appeared as a bulky process on the ventral side, posterior to the ciliated lobes. Under it, near its base, was a short, pointed operculum, which on its inner surface was longitudinally convex and laterally concave. Also the shell had begun to form around the posterior part of the body, originating at a postero-dorsal point where it was attached to the body. Laterally and anteriorly the shell projected far out. The endodermal cells had become much distorted and had lost their symmetrical arrangement, yet retained their great size (Fig. 2*a, b, c*).

On July 17, 2 days after the above-described stage was observed, the opening of another capsule revealed larvae with well-developed shells and with an operculum as previously observed, except that it was much larger and extended beyond the foot laterally and anteriorly. Distinct eyes and otocysts were present at this stage as well as a bilobed ciliated velum, the oral lobes. This was the veliger stage, typical of the gastropod larva (Fig. 2*d, e*). Length of the shell at this stage was 0.20 mm.

After this stage changes in the embryo took place more slowly and no new phases occurred. Some of the existing features merely became more pronounced until the free-swimming stage was attained.

By July 23, after 14 days of incubation, the larvae began to escape normally from their egg cases. The ciliated oral lobes were well extended, and on the free surface of the foot a large purple area appeared. The operculum had lost much of its curvature and was large and broad, extending well beyond the foot both laterally and distally. The whole shell was pitted with shallow depressions and had a slight purplish tinge; a similar tinge was also possessed by the larva (Fig. 2*f, g, h*). At hatching the veliger shell was 0.22 mm. in length (Fig. 2*i, j, k*).

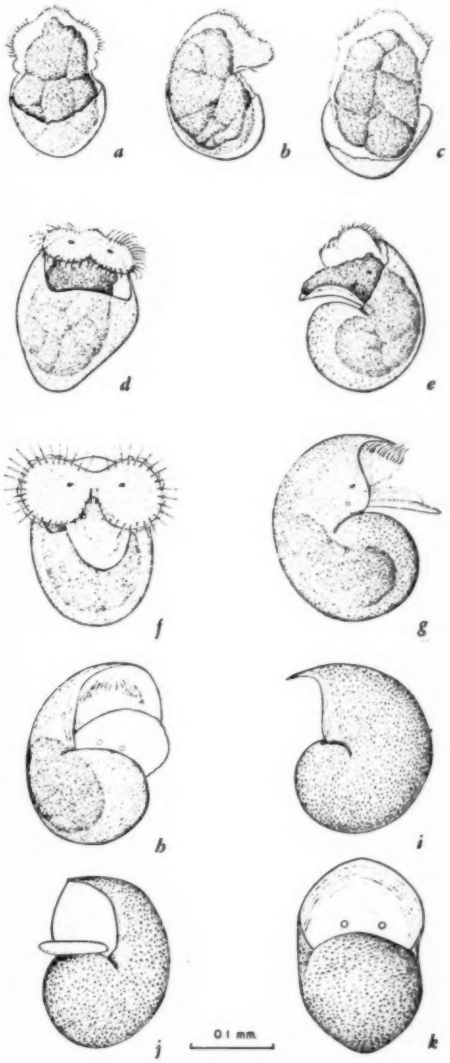

FIG. 2. *Cypraea carneola* Linnaeus. *a–c*, Early stages of shell and operculum: *a*, dorsal, *b*, lateral, *c*, ventral aspects; *d, e*, early veliger stages; *f–h*, free-swimming veliger stage: *f*, ventral, *g*, lateral, *h*, ventrolateral aspects; *i–k*, veliger shell of free-swimming stage showing operculum and otocysts.

Cypraea isabella Linnaeus

Fig. 3

During the night of July 21, 1921, a *Cypraea isabella,* which had been brought to the laboratory a few days before, deposited eggs. There were about 1,500 egg cases in three or four layers, held together by a gelatinous matrix, with the egg cases radially arranged. This egg mass, measuring about 24 x 30 mm., was fixed to the surface of a glass in which the animal was kept and was completely covered by the foot of the animal (Fig. 3*a*). The egg case was somewhat cylindrical in form, about 1.5 mm. long, pale straw color, and contained nearly 200 ova within its thick parchment wall (Fig. 3*b*).

The development of the embryo and characteristics of the veliger are very similar to those of *Cypraea carneola.* The zygote, which is smaller than that of *C. carneola,* 0.11 mm., undergoes cleavage in the same manner, and shows a corresponding difference in size of macromeres and micromeres, as well as a similar relation of these to one another (Fig. 3*c–h*). The gastrula stage is formed entirely by epiboly, the micromeres spreading completely around the macromeres. Owing to this condition no invagination is effected and the spherical form of the ovum is retained. This condition was reached after 3 days of incubation (Fig. 3*i*). In the trochophore stage, which followed, the larva assumed an elongate form and the large endodermal cells took on a distorted appearance. The foot began to develop as did the shell, which could be seen as a rudiment loosely surrounding the posterior part of the body (Fig. 3*j, k*).

The free-swimming stage was reached after 11 days of incubation, when the larva apparently had developed all the characters of the veliger stage. Between the eyes now appeared an arch of bluish-black pigment, and the foot had a large, broad operculum, as in *C. carneola*; also, as in the latter, the entire shell was covered with small, shallow pits.

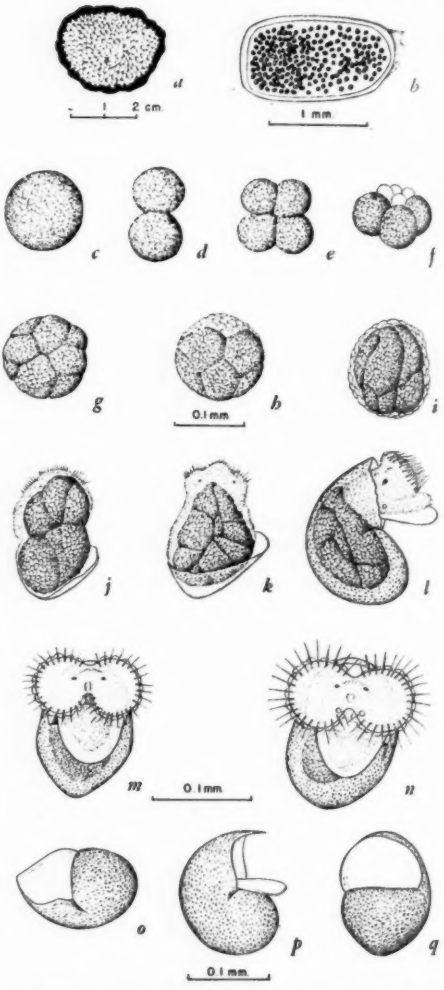

FIG. 3. *Cypraea isabella* Linnaeus. *a,* Egg mass seen through glass and covered by foot of animal; *b,* egg capsule enlarged; *c–g,* cleavage stages; *h,* blastula; *i,* gastrula; *j, k,* trochophore with shell beginning to form: *j,* ventrolateral aspects, *k,* ventral aspect; *l, m,* veliger stage: *l,* lateral, *m,* anterior aspects; *n,* free-swimming veliger; *o, p, q,* shell of free-swimming veliger showing (*p*) operculum.

The outer lip of the shell was purplish-brown; the whole shell, which was about 0.15 mm. long, had a pale tinge of that color (Fig. 3*l–q*).

Some of the larvae which survived until the ninth day of their free-swimming stage gave no evidence of metamorphosis.

Cypraea helvola Linnaeus
Fig. 4

On July 23, 1921, I obtained from a porous rock in shallow water off the laboratory two adult specimens of *Cypraea helvola,* one of which was "sitting" on an egg mass deposited on the rock.

The egg cases, or capsules, numbering about 1,000, were in many layers, imbedded in a gelatinous matrix with their long axes directed radially. The egg mass measured about 13 x 18 mm. (Fig. 4*a*).

The egg case was somewhat oval, about 2 mm. in length, of a pale straw color like those of *C. carneola* and *C. isabella,* and contained about 200 ova. The capsule walls were thinner than those of the other two and quite transparent.

Figure 4*b* shows a magnified capsule with embryos in the veliger stage.

When the egg capsules were obtained, they were found to contain embryos in the gastrula stage and were several days along in their development. The gastrulae were quite spherical and had been produced by epiboly, no sign of invagination being perceptible. The transverse measurement of the embryo in this stage was about 0.09 mm. (Fig. 4*c*).

A little later the gastrula became slightly elongate and a small tuft of minute cilia appeared on each side of the body anteriorly, as in the two preceding species (Fig. 4*d*).

In the course of 3 days these embryos became free-swimming veliger larvae, which bore a close resemblance to those of *C. carneola* of the same stage, except for being much smaller. As in that species, there was a large purple area on the ventral side of the foot (Fig. 4*e, f*).

Some of the larvae were kept in jars with standing water for about a week of their free-swimming stage without showing any perceptible change. Upon hatching they issued from the egg cases simultaneously. The cases were purple, owing to the pigment in the larvae and the transparency of their covers.

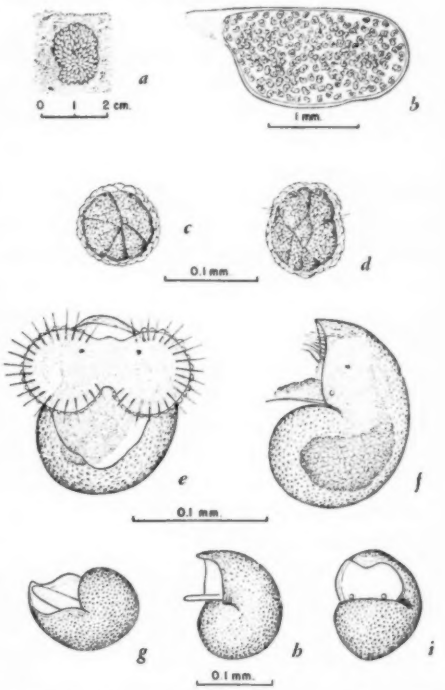

FIG. 4. *Cypraea helvola* Linnaeus. *a,* Egg mass; *b,* egg capsule enlarged with embryos in veliger stage; *c, d,* gastrula stage; *e, f,* free-swimming veliger stage: *e,* ventral, and *f,* lateral aspects; *g–i,* shell of free-swimming veliger showing operculum and otocysts.

The veliger shell measured 0.14 mm. in length, and in a number of specimens from which the dead animals had been removed by protozoan scavengers, opercula and otocysts remained. The pitted surface of the shell resembled that of the two preceding species (Fig. 4*g, h, i*).

Cypraea caputserpentis Linnaeus
Fig. 5

The commonest species of the genus in Hawaii is *Cypraea caputserpentis.* It is com-

monly encountered on the shore rocks washed by the surf during high tide. A considerable number of individuals may be seen in a comparatively small area.

The first successful attempt at obtaining the spawn of this species was made on October 26, 1920, when a specimen which was concealing an egg mass under its outspread foot was found on the shore rocks at Diamond Head. The mollusk and egg mass were taken to the laboratory for study.

The egg mass, consisting of about 100 capsules, was somewhat flattened to accommodate the animal "sitting" on it and was spread out suitably for being covered by the foot. The egg mass measured about 1 x 2 cm. through its horizontal diameters. The capsules were somewhat oblong, measured 2 mm. in length, and contained an average of approximately 200 ova.

About 1½ hours after they had been taken off the rocks, the zygotes were in early cleavage stages, having four or more cells. Subsequent investigations seemed to indicate an abnormal condition of development in which the early embryos assumed a variety of forms, many dying within the capsules. Some of the capsules ruptured in the course of 6 days, liberating embryos long before they had reached the veliger stage; in other capsules the young died. This abnormal condition possibly was caused by a faulty chemical nature of the water.

More satisfactory results were obtained from another egg mass, also taken from shore rocks at Diamond Head. The embryos developed normally to the free-swimming veliger stage, but cleavage and embryonic development were not investigated.

The veliger larva, showing eyespots and otocysts, had a large reddish-brown area between the eyes and on the ventral surface of the foot. A similar color, but much fainter, was also present in the veliger shell, which had a pitted surface similar to that observed in each of the preceding species of the genus. A flat triangular operculum was present, and otoliths were seen, one in each otocyst (Fig. 5*a–f*).

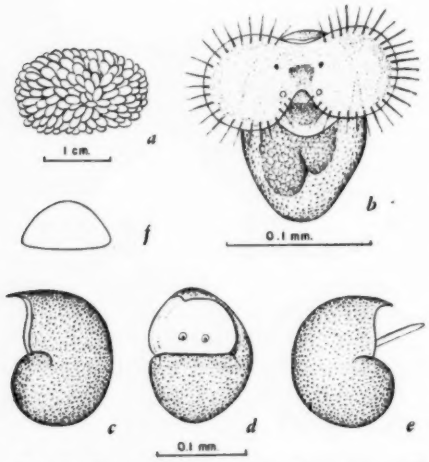

FIG. 5. *Cypraea caputserpentis* Linnaeus. *a*, Egg mass; *b*, free-swimming veliger larva, anterior aspect; *c–e*, shell of free-swimming veliger showing operculum and otocysts with otoliths; *f*, operculum in surface view.

Cypraea mauritiana Linnaeus

Fig. 6

In the morning of June 29, 1925, an egg mass was noticed in one of the aquarium tanks in which two of the mollusks were kept. The egg mass was lying on the bottom of the tank beside a rock to which it had probably been attached. Whether or not the animal had been "sitting" on the eggs, as in other cases observed, could not be said. There were about 300 egg cases in the mass. This may have been only a portion of those laid by the mollusk, inasmuch as some could have been eaten by the fishes which were also in the tank.

The egg cases were of a somewhat triangular form and attached to one another at one or more points but were not imbedded in a gelatinous substance as in other species. The egg case measured about 4 mm. in length and 3 mm. at its widest point. The capsular

wall was very thin and transparent, so that the carmine-colored ova could be seen plainly without breaking the capsule.

The ova, of which there were about 1,000 in a case, averaged 0.15 mm. in diameter. Early in the afternoon of the same day they started to divide. Most of them reached the four-cell stage by 4:00 P.M. The mode of division was the same as that observed in the other species.

Not until the seventeenth day did the larvae begin to leave the egg cases. Development had probably been retarded owing to unsuitable conditions, as many egg cases at that time contained dead embryos only.

The veliger shell, which had attained a length of about 0.235 mm., differed from those of the other species which have here been described, particularly in its sculpturing. While a pitted condition of the surface might have been recognized, closely crowded, rounded granules gave to the shell a distinctive appearance. It had a slight golden tinge, a brown columella, and margin of aperture.

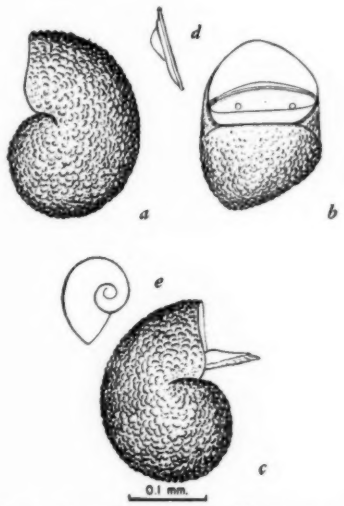

FIG. 6. *Cypraea mauritiana* Linnaeus. *a–c*, Shell of free-swimming veliger showing operculum lodged in shell; *d*, operculum in edge view; *e*, operculum showing spiral turns.

The operculum differed from those observed in the other species by being strongly convex on the surface that attached it to the foot (Fig. 6*a–e*).

Cypraea poraria Linnaeus

Fig. 7

On May 1, 1923, an egg mass of *Cypraea poraria* that was attached to a coral rock from Honolulu harbor was brought to the laboratory. The animal was "sitting" on the egg mass which, at the time it was obtained, was well along in development.

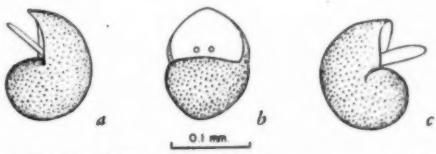

FIG. 7. *Cypraea poraria* Linnaeus. *a–c*, Shell of free-swimming veliger with opercula and otocysts.

A study was made of the veliger shell alone. This measured 0.14 mm. through its greater diameter, or length. It had a very delicately pitted surface of a pale golden-yellow coloration. The operculum, broadly rounded, was slightly concave longitudinally on its free surface (Fig. 7*a*, *b*, *c*).

PROTECTION OF EGGS BY *Cypraea isabella* LINNAEUS AND *Cypraea helvola* LINNAEUS

As I was fortunate enough to obtain eggs from species of *Cypraea* kept in the laboratory during the summer of 1921, it was possible to observe the strong maternal instinct developed in these mollusks as shown by the protection of their eggs.

Cypraea isabella deposited its egg mass on the side of the glass in which it was kept, a few days following its capture. The egg mass, consisting of about 1,500 cases imbedded in a gelatinous matrix, was spread out so as to be conveniently covered by the foot of the animal. Various interesting methods em-

ployed by this mollusk to keep an intruder away made it evident that it was greatly concerned in preventing the removal of any of its eggs.

When an attempt was made to push back the edge of the foot so as to expose the egg cases, the animal would at once move toward the disturbing object and spread out its foot in that direction. When the points of a pair of forceps were placed in front of it, near its head, it would assume an aggressive attitude and advance toward the forceps, touching them or pressing against them with its tentacles and proboscis in a determined manner. But the most striking method employed by the animal to frighten away an enemy consisted of raising the shell as high as possible and then with great suddenness bringing it downward and forward to its normal position, thereby agitating the water around it. These antics would be repeated many times when the animal was disturbed.

Since an enemy from behind or from the sides could not always be seen, the mollusk was guided by touch, to which it was very responsive. When the forceps were placed against the posterior part of the foot, the animal would move back the shell, exposing the posterior part of it by retracting the mantle lobes so the two "eyespots," which are so conspicuous in this species, became visible. Whether this had any significance or not could not be determined. The *Cypraea* did not stop at that, however, for the posterior end of the shell would be brought against the forceps in an attempt to force them away; and by means of the posterior canal of the shell, the animal was able to get a firm hold on the forceps and twist them slightly from side to side. The animal remained constantly on its eggs during the entire 11 days of incubation.

A *Cypraea helvola* with eggs, which was obtained about the same time from a coral rock on the reef, employed, with equal vigor, the methods of defense observed in the above species, with the exception that it did not seem to use the uncovered posterior end of its shell in any way. This species has no "eyespots" on its shell.

The animal remained on its "nest" until the eggs hatched and liberated the veliger larvae, upon which it promptly left, giving no further evidence of interest in its offspring.

Family *MITRIDAE*

Genus MITRA

Mitra astricta Reeve

Fig. 8

On October 17, 1921, I found the spawn of *Mitra astricta* on a rock about 25 meters from shore near the laboratory. There were three adult mollusks on the coral rock containing the eggs, one of them being very close to the egg mass, which was freshly laid. This was taken as good evidence of parentage until later verification could be furnished.

The egg cases, about 100 in number, were separately attached within a cavity of the rock, each one adhering firmly to the firm substratum of the rock by means of a tough, parchment-like base. The egg case was about 2½ mm. in length, club-shaped or oblong, and consisted of a thin, tough, fibrous capsule of a pale straw color. At the attached end this capsule was continuous, forming a stout, broad base by means of which it adhered to the rock (Fig. 8*a*). The albuminous fluid with which the capsule was filled contained from 100 to 150 ova (Fig. 8*b*).

The zygotes were 0.14 mm. in diameter and the type and rate of cleavage were similar to those that had been observed in species of *Cypraea* and *Conus*. In many instances, however, the first division resulted in unequal cleavage, but this might have been an abnormal condition. After the first division, in what appeared to be the normal, or usual, condition, the two equal-sized blastomeres contracted so as to produce an oval body of the two daughter cells. Such a contraction

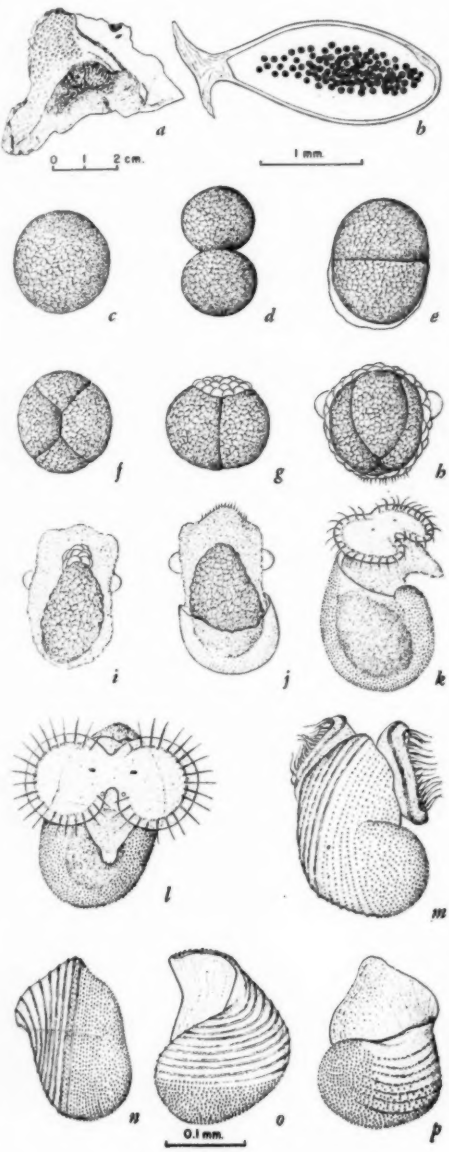

FIG. 8. *Mitra astricta* Reeve. *a*, Egg capsules attached to rock; *b*, enlarged capsule; *c–g*, cleavage stages; *h*, blastula stage; *i*, gastrula stage; *j*, embryo showing rudiment of shell; *k*, veliger; *l*, *m*, free-swimming veliger: *l*, ventral, and *m*, dorsal aspects; *n–p*, shell of free-swimming veliger larva.

of the blastomeres after the first and second divisions seems a usual condition in the gastropods, but it was more pronounced in this case than generally. Cleavage proceeded rather slowly at first, the four-cell stage having been reached only after 24 hours; the following 24 hours presented a stage in which 20 or more micromeres capped the animal pole. There were four macromeres (Fig. 8*f*, *g*).

After 3 days of development the micromeres had greatly increased in number and constituted about one-half of the surface area of the embryo; a number of those near the vegetal pole had developed short cilia, while the four large macromeres were as yet undivided. Projecting out from each side of the embryo was a large micromere, clear like the others, about half of its sphere protruding beyond the surface of the ectoderm. This stage was evidently comparable to the blastula, although the space required for the segmentation cavity was entirely obstructed by the large macromeres (Fig. 8*h*).

A day later—after 4 days' development—the embryo had become elongate and the micromeres had surrounded by a complete layer (ectoderm) the dark, conspicuous macromeres, which also had taken on an elongate form, but the boundaries of which had now become so obscure that it was impossible to determine their number. At the anterior end of the macromeres there was a cluster of rather large, clear cells, probably mesodermal. Anteriorly the ectodermal layer, in connection, perhaps, with an underlying mesoderm, had developed three slight lobes, the rudiments of the velum. Cilia could not be seen although they must have been present as the embryo showed considerable activity. This was the gastrula stage (Fig. 8*i*).

After the sixth day a shallow cup-shaped shell surrounded the posterior region of the embryo (Fig. 8*j*). Seven days of development brought out the veliger stage. A bilobed ciliated velum which had minute eyespots was found. A short pyramidal foot was

present, and a finely granulated shell surrounded the greater part of the larva (Fig. 8*k*).

From this time on, development proceeded rather slowly, no marked changes taking place until the free-swimming stage was reached, after 14 days of incubation. The velum consisted then of two circular lobes with a double line of purplish-pink around the borders. Eyes and otocysts were present. The foot terminated in a blunt translucent tip set with bristles. The operculum was observed in only one specimen and was small and rudimentary (Fig. 8*l*, *m*). The first whorl of the shell started with a corkscrew spiral as in the common snail. The apex was sprinkled with granulations which tended to be in rows distally; while the distal half of the veliger shell was ornamented with granular spiral ridges. These ridges seemed to correspond to the transverse striae on the whorls of the adult shell. The shell was colorless and about 0.22 mm. long (Fig. 8*n–p*).

Mitra auriculoides Reeve

Fig. 9

On December 21, 1923, while collecting on the reef about 15 meters offshore near the laboratory, I found a group of egg cases attached to the undersurface of a rock, accompanied by a *Mitra auriculoides*. There could hardly be any more doubt that the egg cases belonged to this mollusk than in the case of *Mitra astricta* obtained 2 years before under similar circumstances. Furthermore the comparison of egg capsules, veliger larvae, and shells bore out this conclusion.

The egg cases, about 100 in number, were crowded closely together and occupied nearly 2 square cm. of the rock surface. The egg case, resembling greatly that of *Mitra astricta*, was club-shaped, about 4 mm. in length, and was attached to the rock at one end by a basal extension. The capsule wall was very thin and there were about 200 ova to the capsule.

When the egg mass was found the capsules contained embryos in an advanced veliger stage, the coloring of which imparted a pale brownish tinge to the capsule (Fig. 9*a*, *b*).

On December 28, the young escaped from their enclosures, and the close resemblance to both larva and shell of *M. astricta* was obvious. The same double band bordering the veliger lobes was present, and the ridges and granulations on the shell were distributed as in the other species. The operculum, however, showed a marked difference; while it was almost absent in *M. astricta*, it was well developed in this species. The foot was pro-

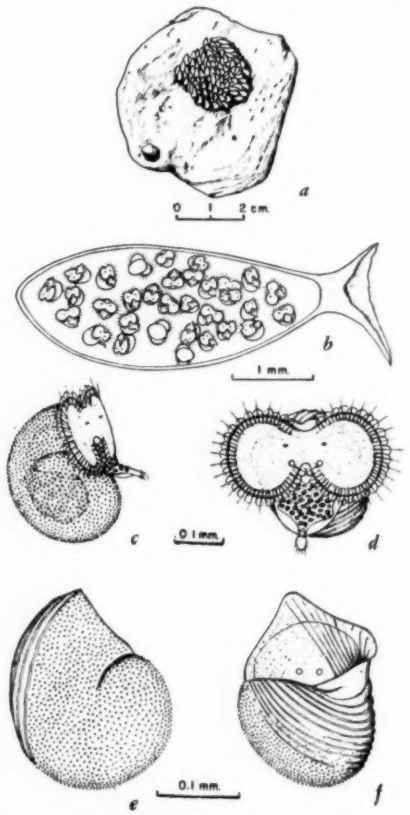

FIG. 9. *Mitra auriculoides* Reeve. *a*, Egg capsules on rock; *b*, magnified capsule with embryos in veliger stage; *c*, *d*, free-swimming veliger; *e*, *f*, shell of free-swimming veliger.

duced laterally into two angular processes, and anteriorly, as in *M. astricta,* into a blunt, rounded process with bristles. Eyes and otocysts were present. The marginal bands on the velum were greenish-brown. Numerous spots of the same color occurred also on the foot. The length of the shell was 0.25 mm. (Fig. 9*c–f*). The larvae showed a strong positive phototropism.

Family *CONIDAE*

Genus CONUS

Conus tahitensis ra'tus Hwass

Fig. 10

While collecting on the outer reef near the Elk's Club at Waikiki during the morning of August 4, 1921, I picked up a specimen of *Conus tahitensis* in the act of depositing eggs. I broke off the rock to which the egg capsules were attached and took it to the laboratory.

There were 22 egg cases of a soft, thin structure and of a comparatively large size, about 11 x 15 mm. Each egg case contained about 2,000 ova of rather small size, 0.125 mm. (Fig. 10*a*).

The ova, in respect to distribution of yolk (deutoplasm) and cytoplasm, agreed closely, insofar as could be observed without special preparations, with those of *Cypraea* and *Mitra.*

The early stages of cleavage were observed in a capsule about 6 hours after deposition. The first division resulted in two cells of equal size. These rounded out independently until the two cells were joined to each other by a very small area. Soon they contracted toward each other to assume the appearance they had before the first division was complete (Fig. 10*b, c, d*). The second division, resulting in four cells of equal size, had occurred about 1 hour after the first. Here again, as in the first division, the cells were rounded off and standing out prominently.

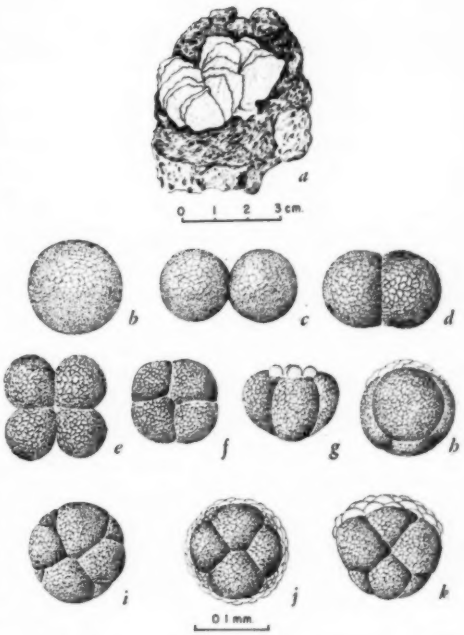

FIG. 10. *Conus tahitensis rattus* Hwass. *a,* Egg capsules attached to rock; *b–k,* cleavage stages from the ovum to the blastula stage.

These again became pulled toward the center, so that the entire mass became neatly spherical (Fig. 10*e, f*). The next cleavage was unequal, resulting in four micromeres and four macromeres, as in *Cypraea* and *Mitra* (Fig. 10*g*). Succeeding cleavages resulted in a cap of micromeres at the animal pole. The macromeres now divided nearly equally into four cells of lesser size which came to lie at the equator, and four larger ones which surrounded the vegetal pole. The micromeres soon extended to the equator, covering half of the sphere of the embryo and projecting out beyond the macromeres (Fig. 10*b, i, j*).

This was the blastula stage and the embryo now began to show activity. It appeared that in some of the embryos another division of the four equatorial macromeres had taken place, as some embryos had 12 macromeres

This was also observed in *Cypraea carneola* and is probably a common condition (Fig. 10*k*). Owing to the loss of all the larvae, no further observations on the development were made.

In February, 1923, another *Conus tahitensis* with egg capsules was found near the laboratory. The egg capsules were much smaller, but agreed in other respects with the one described, i.e., in color, texture, number, and size of ova. As in the previous lot none developed beyond the blastula stage.

Conus omaria Hwass

Fig. 11

On May 19, 1921, I found, near the laboratory, a number of *Conus* egg cases which were attached to the underside of a rock. Under this rock also was an adult *Conus omaria*, a rather rare species on this reef. The egg capsules differed from all those previously observed in that only a few of them were attached directly to the rock; the greater number, about 34 in all, were joined to one another, forming arches and bridges (Fig. 11*a*).

Upon examining the contents of one of these capsules, I found zygotes in very early cleavage stages. Some were still unsegmented, while a number were in the two-cell stage, the result of an equal division. A few had undergone a second division which was equal, four blastomeres of a smaller size resulting.

The capsules of this species, measuring about 11 mm. in length and 8 mm. in width, contained a small number of large ova, 0.47 mm. in diameter, often less than 50 in one capsule. The zygotes failed to develop when removed from the capsule, so it was necessary to open one each day to follow their progressive development. Five days after they were obtained some of the embryos had begun to form a shell. And after 11 days of incubation they had attained well-advanced stages, a large shell having formed about the

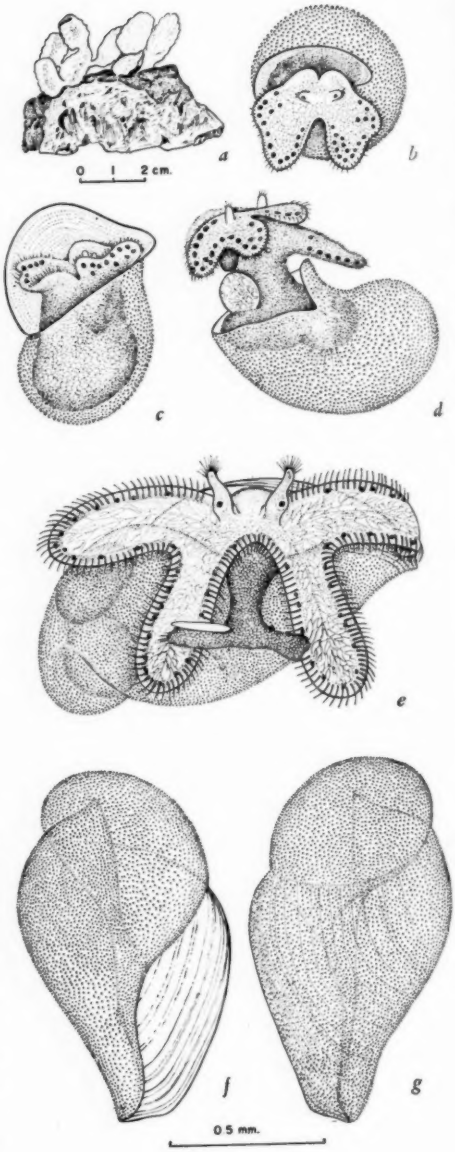

FIG. 11. *Conus omaria* Hwass. *a*, Egg capsules attached to rock; *b–d*, stages of development in veliger larva, heart showing as a globular body in *d*; *e*, veliger larva after normal release from capsule; *f*, *g*, shell of veliger larva.

body. The veliger lobes had also attained a large size, yet the cilia bordering them remained short. The heart could be seen distinctly as a single-chambered oval bag on the dorsal side posterior to the veliger lobes. Its alternate contraction and expansion would change its volume about 100 per cent. The large veliger lobes were bordered by a single row of yellowish pigment cells. A pair of blunt papilla-like tentacles supporting the eye were tipped with a few short bristles. The shell showed a fine granulation. No operculum was present on the large foot (Fig. 11*d*).

At the sixteenth day of incubation some changes were noticeable. The two veliger lobes had developed greatly, each having a deep lateral indentation. The cilia also had increased greatly in size and were beating rhythmically, keeping the animal upright with the apex of the shell against the bottom. The large bilobed foot supported a small operculum on one of its lobes and was covered with very fine cilia; a few prominent bristles were present at its opercular end. Two prominent tentacles, bearing the eyes on basal swellings and beset at their extremities with a large tuft of bristles, occupied a central position on the veliger lobes (Fig. 11*e*).

At this stage, 16 days of incubation after the beginning of cleavage, the larvae began to escape into the water, but, unlike those of other species here observed, they remained within the albuminous substance of the capsule which had been discharged into the water and did not attain the power of swimming at any time while under observation. This inability to swim may be ascribed to the great size and weight of the shell, some of the veliger shells having attained a length of over 1.25 mm. with about one and a half volutions (Fig. 11*f, g*). A fine granulation covered its entire outer surface, which had taken on a faint golden tinge, most pronounced anteriorly. The columella seen through the quite transparent shell had a pale rose tinge. This coloration of the veliger shell is an approach to that in the shell of the adult.

Egg capsules corresponding to those of *Conus omaria* were found near the Marine Laboratory, May 25, 1922, but were of a larger size than the first lot. These capsules contained advanced veligers, one capsule containing about 40, another as many as 150 embryos. Some of the larvae of this lot were kept for over a week after their escape from their capsule without ever showing signs of swimming. Some, however, would drag their shells on the bottom of the dish by means of the propelling force of their velar cilia. A number of the larvae were normally expelled from the capsule, which seemed to be effected by a dissolution of the "window" at the free, or distal, end of the capsule, followed by a contraction of the capsular walls, resulting in a squeezing out into the water of the albuminous substance containing the larvae. It may be that both chemical and mechanical agents are responsible for this occurrence, and that the larvae, at the time of their liberation, emit some secretion which brings about the desired results.

A circumstance which might be correlated with the absence of a free-swimming stage of this species is the fact that *Conus omaria* occurs in many varietal forms in various parts of the Hawaiian Islands; so much so that some authorities are inclined to consider some of them distinct species.

One might suppose that the free access to widespread areas possessed by those species having such an efficient mode of dispersal as a pelagic veliger larva would serve to break down varietal strains which might be in process of development and thus tend to stabilize the species, whereas an immotile larva, as here observed in *Conus omaria,* would have the opposite effect.

Conus catus Hwass

Fig. 12

On June 12, 1922, a mass of egg capsules

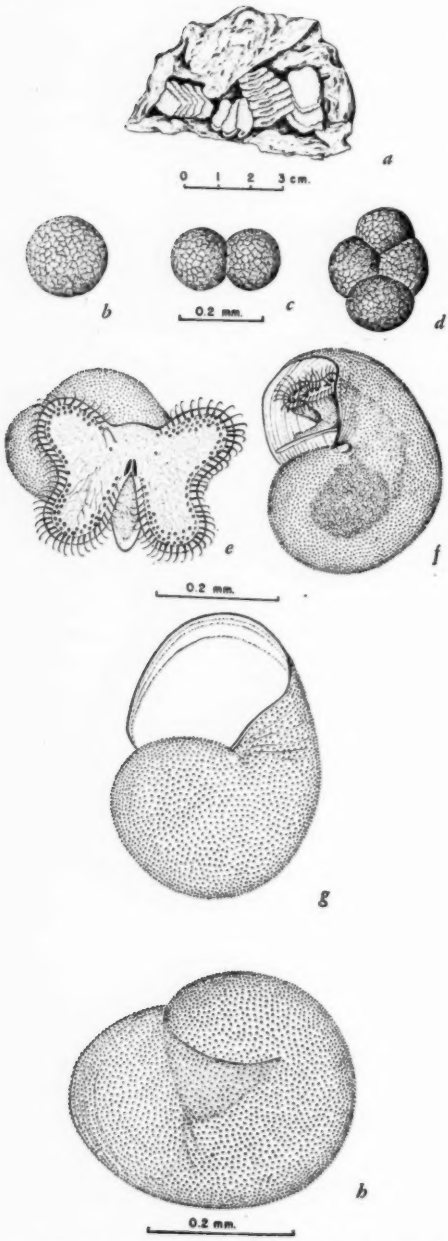

FIG. 12. *Conus catus* Hwass. *a*, Egg capsules attached to rock; *b–d*, cleavage stages; *e*, *f*, free-swimming veliger larva; *g*, *h*, veliger shell of free-swimming larva.

attached to a rock with a *Conus catus* beside it was found near the Marine Laboratory. These capsules, of a pale straw color, were thin, semi-transparent, yet firm and rigid, measuring about 9 x 12 mm., and containing from 500 to 1,000 ova (Fig. 12*a*).

The diameter of the zygotes averaged 0.2 mm., and cleavage was similar to that observed in other species of the genus, i.e., equal in the first and the second division, unequal in the third (Fig. 12*b, c, d*).

The larvae attained the free-swimming veliger stage in 15 to 16 days, at which time the shell measured about 0.375 mm. in length. The velar lobes were of medium size with a lateral indention which partly divided them, but to a far less extent than in the veliger of *C. omaria*. The lobes were bordered by a continuous line of many pale green pigment spots which were increased in number at the extremities of the lobes so as to form two or three rows. Eyes were distinct with a rather short tentacle at the right eye. The mouth was marked by an elongate black streak on each side. The foot was somewhat narrow and pointed, bearing an operculum which extended well beyond it distally. Fine bristle-like processes were present (Fig. 12*e, f*). The shell was ovate and densely granulate, consisting of about one spiral turn. Some of the shells had a faint reddish tinge on the outer lip (Fig. 12*g, h*).

Conus hebraeus Linnaeus

Fig. 13

On March 22, 1921, a *Conus hebraeus* kept in the laboratory in a pan of water was found in the act of laying an egg case. Further inspection of the pan resulted in the discovery of other cases. The egg case being laid was partly held by the animal and was of a jelly-like consistency. Upon contact with the water, the capsular walls gradually hardened and it assumed the appearance of the other egg cases. The capsules were very pale straw

colored with corrugated distal margins. They were almost square and measured about 10 mm. across (Fig. 13*a*).

Cleavage was not investigated in this species. After a period of 9 days the embryos had begun to show activity, short cilia having developed in three regions near the anterior end of the body. A shell had also begun to form, taking the form of a slipper, and beginning, apparently, at a dorsoposterior region of the body of the embryo, at which place it was attached (Fig. 13*b, c*). As growth of the shell progressed, it spread to the side, becoming cup-shaped. This stage was observed 1 day later (Fig. 13*d, e*).

In the course of 24 hours an interesting transitional stage occurred. The lateral ciliated areas constricted to form veliger lobes. The cilia grew rapidly and other cilia appeared along the borders of the lobes; the anterior cilia remained short, as did those now visible on the foot. The veliger lobes gradually unfolded and the embryo began to assume the appearance of the free-swimming form. The shell covered the greater part of its body.

The embryo quickly grew into the free-swimming larva as the veliger lobes were completely unfolded and the cilia became capable of propelling the animal through the water. Since simultaneous development of the embryos in the capsule is not the rule, a provision seems to have been made for those that have been retarded in that the capsule does not expel its contents of young in favor of a minority, but remains closed until the great majority have reached the stage where the new environment becomes imperative.

At the free-swimming stage the rather orbicular veliger lobes were bordered with a row of pale-green pigmented cells; bristles projected from the tip of the ciliated foot, which was without an operculum and pointed. Eyes were present. The shell, measuring 0.28 mm. in length, bore a fine granulation (Fig. 13*f, g*).

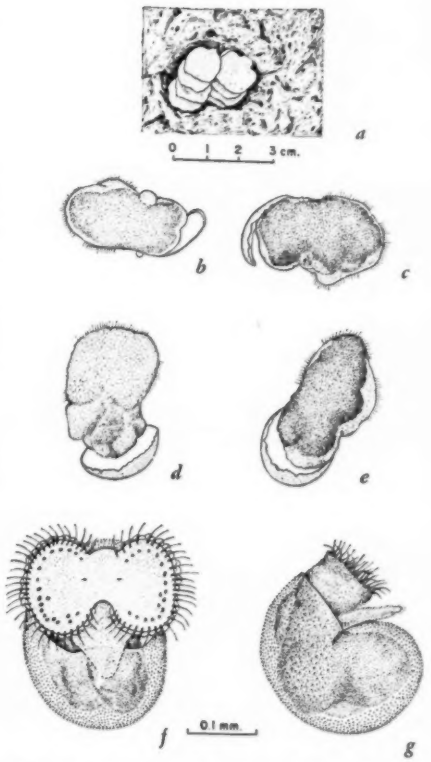

FIG. 13. *Conus hebraeus* Linnaeus. *a*, Egg capsules attached to rock; *b, c*, trochophore larvae showing beginning of shell formation after 9 days of incubation; *d, e*, trochophore stage after 10 days incubation; *f*, free-swimming veliger, ventral aspect; *g*, free-swimming veliger, lateral aspect.

Conus sumatrensis Hwass
Fig. 14

May 16, 1921, while collecting about 50 meters off the Marine Laboratory, I found a group of 34 egg cases of *Conus* attached to the lower side of a piece of coral, and right beside them was a *Conus sumatrensis*. Inasmuch as the zygotes were in very early stages of cleavage, there could be little doubt as to their identification.

The egg cases, quite unlike those of other known species of *Conus* described in this paper, are very soft and thin; they average

13 x 20 mm. Thousands of ova, which in this species were quite small (0.14 mm.), were contained in a capsule (Fig. 14*a–d*). Early cleavage stages only were observed. Numerous polar bodies were seen with them.

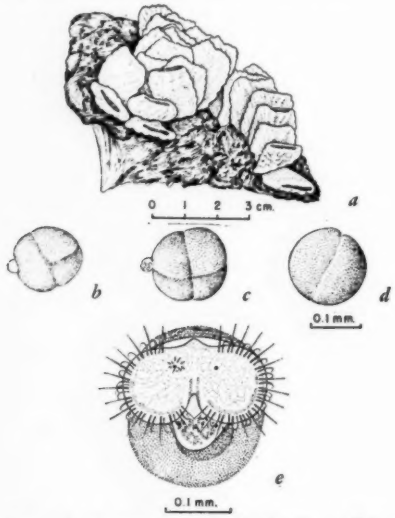

FIG. 14. *Conus sumatrensis* Hwass. *a*, Egg capsules attached to rock; *b–d*, cleavage stages showing polar bodies; *e*, free-swimming larva, ventral view.

After 4 days of incubation the embryos began to show activity and a shell had begun to form. After 7 days the anterior end of the embryo had assumed a trilobular form with short cilia. A shell covered the greater part of the body. On the twelfth day of incubation the young began to leave their capsules, entering upon their free-swimming larval stage. The veliger lobes were rounded and pigmented with green as in *C. hebraeus,* but unlike the larva of that species, a rounded foot, with an operculum projecting beyond it, was present. The shell, which measured 0.25 mm. in length, was covered with a fine granulation (Fig. 14*e*).

Conus abbreviatus Nuttall
Fig. 15

On March 15, 1923, a dozen egg capsules

FIG. 15. *Conus abbreviatus* Nuttall. Egg capsule attached to rock.

were deposited by a *Conus abbreviatus* which had been isolated in the laboratory. The capsules averaged 8 x 10 mm., had firm and rigid walls with smooth sides and margins, except for the distal margins, which were slightly corrugated (Fig. 15). A slight reddish tinge was discernible. Cleavage and larval development were not investigated.

The egg capsules of *Conus* have not been of uncommon occurrence in the shallow water of the Waikiki reef near the Marine Biological Laboratory. Several different forms have been found and specific distinction could often be made by the differences in size, shape, and firmness, and perhaps to some extent by color. A comparison between ova and veliger larvae of a few unidentified capsules, with ova and veligers of determined species, has shown a corresponding distinction. In other words, specific characters may be recognized in the egg capsules.

The capsules in all the species under observation had tough parchment-like walls with more or less corrugated borders. A slit through which the young might escape when they reached the free-swimming stage was present at the distal end of the capsule. During incubation this slit was closed by a clear, semi-transparent substance which then appeared as a window. My observations have not convinced me that the young may not also be released by a rupture of the capsule.

The following species of *Conus* have been found in the living state within wading distance of the Marine Laboratory:

C. abbreviatus Nuttall
C. catus Hwass
C. flavidus Lamarck

C. hebraeus Linnaeus
C. imperialis Linnaeus
C. lividus Hwass
C. miles Linnaeus
C. nanus Broderip
C. omaria Hwass
C. sumatrensis Hwass
C. tahitensis rattus Hwass

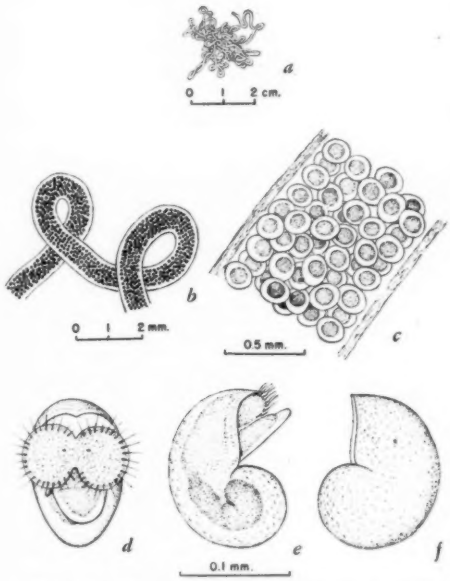

FIG. 16. *Clava obeliscus* (Bruguiere). *a*, Egg filament; *b*, portion of filament enlarged; *c*, section of filament highly magnified; *d*, *e*, free-swimming veliger larva: *d*, ventral, and *e*, lateral aspects; *f*, shell of free-swimming veliger.

Family *CERITHIDAE*

Genus CLAVA

Clava obeliscus (Bruguiere)

Fig. 16

An egg filament of *Clava obeliscus* was deposited in a dish by a specimen of the mollusk on March 28, 1922.

The egg structure was a pale cylindrical filament about 0.75 mm. in diameter, twisted and coiled upon itself to form a tangled mass. The parchment-like walls of the filament were thick and fibrous. The filament contained a closely packed mass of ova, lying about five abreast in cross section. The ovum, measuring about 0.9 mm. in diameter, was surrounded by a hyaline membrane whose diameter was about twice that of the ovum (Fig. 16*a*, *b*, *c*). Development was not investigated. The embryos reached the free-swimming veliger stage in the short period of 6 days. The larva was of a pale straw color. Eyes were present, as well as otocysts; the veliger lobes were rather small, but the operculum was large and rounded. The shell was about 0.16 mm. in length and slightly pitted, much resembling that of the *Cypraea* veliger (Fig. 16*d*, *e*, *f*).

Family *STROMBIDAE*

Genus STROMBUS

Strombus maculatus Nuttall

Fig. 17

In a dish containing two specimens of *Strombus maculatus* several egg structures were deposited on March 16, 1922. These egg structures, which were lying unattached on the bottom of the dish, consisted of a

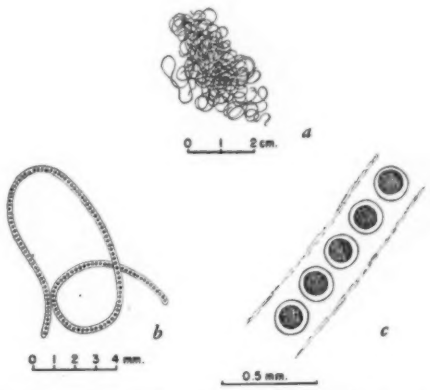

FIG. 17. *Strombus maculatus* Nuttall. *a*, Egg filament; *b*, filament enlarged; *c*, section of filament highly magnified.

maze of very fine pale-yellow threads of various lengths, tangled and glued together as if they were one continuous coil. When magnified, the thread proved to be a cylindrical gelatinous tube with a single row of ova placed in its center and strung out like a single strand of beads, each ovum being surrounded by a globular membrane.

The diameter of the filament was about 0.25 mm., that of the membrane 0.13 mm., and that of the ovum about 0.10 mm. (Fig. 17*a, b, c*). The zygotes died at the morula stage.

Family *MURICIDAE*

Genus MORULA

Morula dumosa (Conrad)

Fig. 18

On July 1, 1923, an egg filament was laid in the laboratory by a specimen of *Morula dumosa* which had been kept for some time. This was a white, cylindrical filament of about two volutions and of about 25 mm. in length. The walls of the coil were fairly thick and the cavity was packed with ova. Each ovum was enclosed in a hyaline envelope of a circular to oval shape, the ovum within measuring about 0.03 mm., therefore among the smallest recorded in this paper (Fig. 18*a, b*).

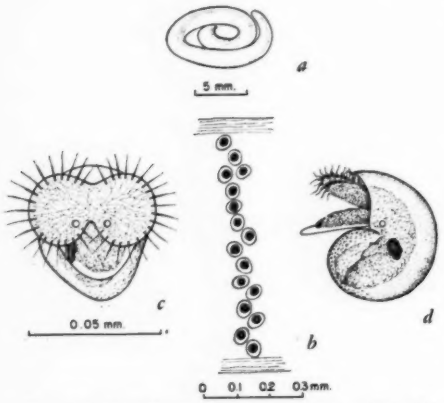

FIG. 18. *Morula dumosa* (Conrad). *a*, Egg filament; *b*, section of filament magnified; *c, d*, free-swimming veliger larva: *c*, ventral, and *d*, lateral aspects.

The free-swimming veliger larva was of a pale-brownish tinge with a large black pigment spot near the base of the foot. Otocysts were present but not eyes. The veliger lobes were round and bore large cilia. Foot and operculum were well developed (Fig. 18*c, d*).

Family *DOLIIDAE*

Genus TONNA (= DOLIUM) (Linnaeus)

Tonna perdix (Linnaeus)

Fig. 19

On June 22, 1924, Ted Dranga, an experienced diver and collector of marine organisms, located near Kapapa Island, Kaneohe Bay, what appeared to be the egg structure of *Tonna perdix*. There were several of these structures about 3 meters from a group of the mollusks. The largest egg structure was nearly circular in form with a diameter of about 15 cm. and with a thickness of about 2 mm. An indentation of about 6 cm. occurred at one side, by which the structure had its attachment, so the form of it is not unlike that of a leaf of a pond lily.

Within the thick parchment walls were 3,076 egg envelopes, neatly arranged in semicircular rows. These egg envelopes were cylindrical with rounded ends, measured about 1 x 2 mm., and contained an average of 49 ova. An estimate of the number of ova in the total structure is 150,724. The ova were rather large, averaging about 0.30 mm. in diameter, and were grouped together within their envelopes so as to form elongate masses with a constriction at the middle. They had a pale-orange tinge (Fig. 19*a, b*).

When the egg structures were brought to the laboratory, the zygotes were in early stages of cleavage. Some were probably in the morula stage, having four macromeres

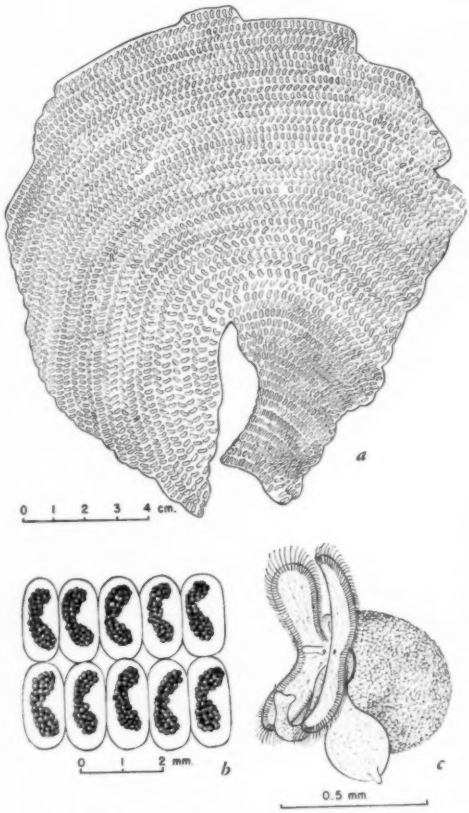

FIG. 19. *Tonna (= Dolium) perdix* (Linnaeus). *a*, Egg structure; *b*, egg envelopes with grouped masses of ova; *c*, free-swimming veliger larva showing a prominent proboscis.

and numerous micromeres, the latter reaching about to the equator. A day or two later a stage in which the embryos showed a slight amount of movement was attained. This was probably the blastula stage, the segmentation cavity being occupied by the large macromeres.

The length of time required for the larva to become a free-swimming veliger was not recorded. At this stage the larva was provided with large veliger lobes, eyes, a long proboscis, and a rounded foot with an operculum extending beyond its borders. A pale-yellow color was seen in the animal's visceral mass. The shell, measuring 0.55 mm. in length, was covered with a fine reticulum of slightly elevated polygonal areas (Fig. 19*c*). It was tinged with carmine along the margin.

It is of interest to compare the egg structure and larva of this species with those of one recorded from the Iranian Gulf by Gunnar Thorson (1940: 192–195).

Family *LITTORINIDAE*

Genus LITTORINA

Littorina pintado Wood

Fig. 20

A large quantity of eggs was obtained from a number of specimens of *Littorina pintado* which were kept in a glass of water in the laboratory. The eggs were deposited during the night and in the morning were found scattered in profusion over the bottom of the glass.

Each ovum, contained within a hyaline membrane, was usually enclosed in a capsule alone; rarely two or more ova were present. The capsules were somewhat globular or pyriform, flat on one surface and convex on the other with a transverse diameter of the flat

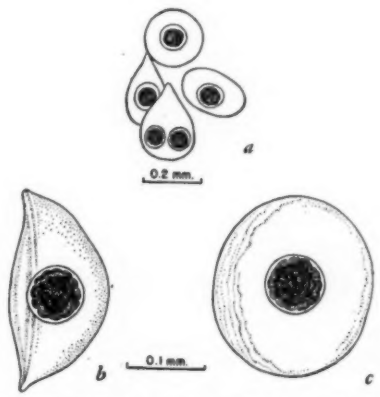

FIG. 20. *Littorina pintado* Wood. *a*, Egg capsules enlarged; *b*, *c*, egg capsule magnified, and seen from edge and flat surface.

surface of about 0.19 mm. The ovum measured about 0.08 mm. (Fig. 20*a, b, c*). Development of the ova was not investigated.

It is of interest to compare the egg capsules and ova of this species with those of two other species of the genus from Bermuda, which have been recorded by Dr. Marie V. Lebour. They are *L. zigzac* Dillwyn (Lebour, 1945) and *L. neritoides* (Lebour, 1935).

Order OPISTHOBRANCHIATA
Suborder TECTIBRANCHIATA
Family *APLYSIDAE*

Genus TETHYS (= APLYSIA)

Tethys (= Aplysia) grandis (Pease)
Fig. 21

On November 9, 1920, two egg filaments of *Tethys grandis* were found beside the Marine Laboratory pier adhering to a stone under which were two of the animals. Since then numerous filaments have been seen on the loose stones at the same place, to which the mollusks come in large numbers. They were especially abundant during the months of November, December, and January, which seemed to be the main spawning season. They were also present at other times of the year, in August for example, and their spawn would invariably be found with them.

The filament of this mollusk resembled a very tangled bundle of yellow thread with a circumference of about 15 cm. and a thickness of about 3 cm. It was supplied with thick walls and contained masses of oval or rounded hyaline membranes packed together throughout its length. These hyaline membranes lay 3 or 4 abreast in the filament and each contained 7 to 15 ova (Fig. 21*a, b*).

Early stages of cleavage were investigated in different filaments of the species. In one instance, the first cleavage was equal, the second unequal and resulted in two smaller blastomeres asymmetrically placed. This would indicate spiral cleavage. The ovum measured about 0.085 mm. (Fig. 21*c–f*).

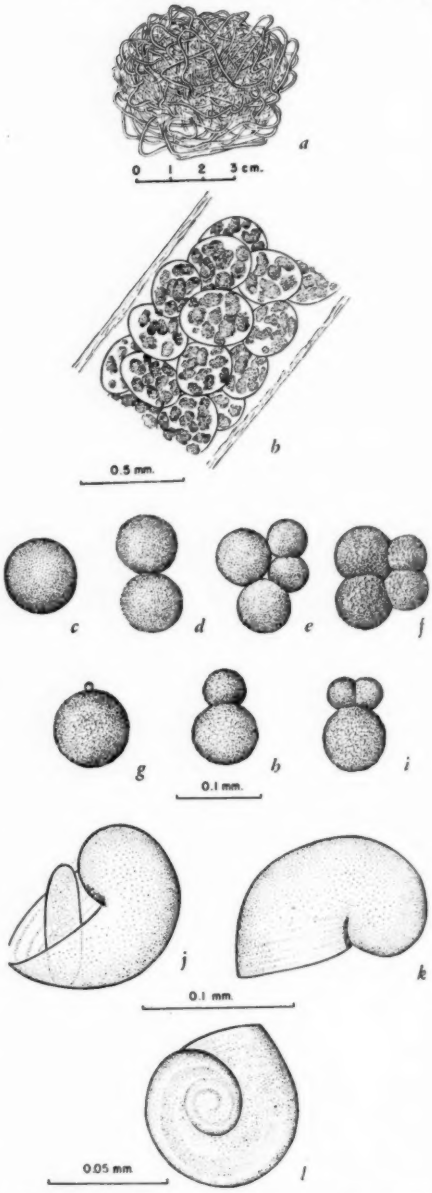

FIG. 21. *Tethys (= Aplysia) grandis* (Pease). *a*, Egg filament; *b*, magnified section of filament with active embryos; *c–f*, first type of cleavage; *g–i*, second type of cleavage; *j*, *k*, shell of free-swimming veliger stage showing operculum (*j*); *l*, operculum more highly magnified.

A month later in the season another type of cleavage was observed in which the first was unequal and the second resulted in an embryo with three blastomeres, only the smaller blastomere of the first division having divided (Fig. 21*g*, *h*, *i*).

The total period required for incubation was not recorded. The free-swimming larva was provided with a coiled shell and a large, rounded operculum (Fig. 21*j*, *k*, *l*). The free-swimming veliger larvae were kept 21 days in a large glass container in the laboratory. During this period no indication of metamorphosis into the adult condition was discernible; only a slight growth of the shell could be detected.

After several days of incubation the hyaline envelopes within the filaments could be seen to contain a whirling mass of embryos in various stages of development, as well as zygotes in early cleavage stages. The obvious effect of this action seemed to result in the survival of the stronger and more advanced embryos over the weaker and retarded individuals, which were knocked to pieces and consumed by the stronger. Thus, a form of cannibalism existed (Fig. 21*b*).

Inasmuch as this mollusk is of quite common occurrence inshore during the cooler season of the year and is a very prolific egg layer, its spawning habit could be observed in the laboratory, where several of the animals were kept in a trough with running water in which a number of coral rocks were placed which bore algae and other marine organisms.

When the animal deposited its filament, it mounted the rough surface of a coral rock and placed the right side of its head against the surface of the rock, bringing the adhesive filament into contact with it. The filament passed along the genital groove between the parapodial lobes on to the right side of the head.

As the filament was extruded, the animal turned its head from side to side in a desultory fashion with the result that successive loops formed an irregular, tangled, thread bundle adhering to the rock. One such filament was found to have a length of 5.25 meters when it was unraveled. It contained an estimated number of ova reaching the high figure of 742,720.

Freshly deposited filaments were pale yellow, but as the embryos developed the filaments became quite brown. Under favorable conditions of development, the free-swimming young were seen to escape simultaneously in great swarms, the egg filament being literally torn to bits.

Tethys (= Aplysia) bipes (Pease)

Fig. 22

Like the preceding species, this large form occurred commonly under loose stones along

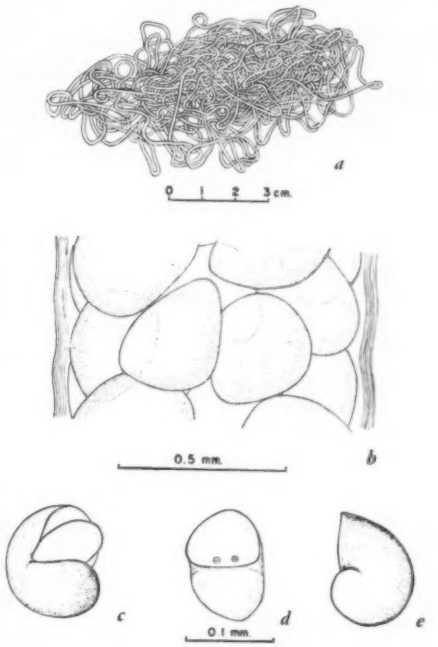

FIG. 22. *Tethys (= Aplysia) bipes* (Pease). *a*, Egg filament; *b*, section of filament magnified to show egg envelopes; *c–e*, shell of free-swimming veliger showing operculum and otoliths.

the shore during the cooler months of the year, at which time its filaments were also found in abundance. As in the preceding species the fresh filament was white or pale yellow and, as development of the young progressed, it turned to a yellowish-brown.

The structure of the filament and the type of cleavage agreed in nature with those of *T. grandis*. However, a note on the veliger shell is of interest. The shell measured about 0.125 mm. in length and consisted of about one volution, was a light golden-brown in color, darkest along the columellar line. The operculum was large and round as in *T. grandis*. Otoliths appeared distinctly within the otocysts (Fig. 22*c, d, e*).

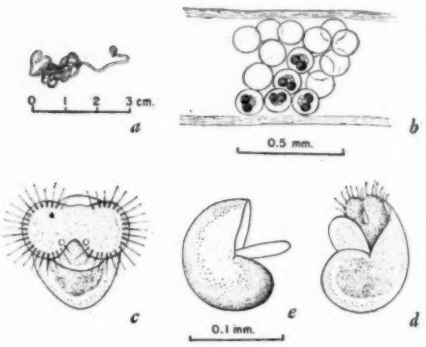

FIG. 23. *Tethys (= Aplysia) elongata* (Pease). *a*, Egg filament; *b*, magnified section of filament with early cleavage stage; *c, d*, free-swimming veliger larva; *e*, shell with operculum of free-swimming veliger.

Tethys (= Aplysia) elongata (Pease)

Fig. 23

Early in March, 1923, a specimen of *Tethys elongata* found near the Elk's Club, Waikiki, was brought to the laboratory. This animal was in general of a much darker color than the species but otherwise seemed to agree and might be considered a color variety. Two months later five more specimens like it were found in the same location.

An egg filament was deposited by this mollusk in the laboratory. This was a pale green, tangled, cylindrical filament of about 0.5 mm. in diameter. The lumen of the filament was closely packed with globular hyaline capsules with an average diameter of 0.125 mm., lying about four abreast in a cross section and each containing one ovum.

The first cleavage of the zygote was usually equal, while the second was unequal, resulting in two micromeres and two macromeres. The micromeres soon divided, giving the embryo its triangular appearance, corresponding, perhaps, to the morula stage (Fig. 23*a, b*).

The free-swimming veliger stage was reached in 11 days, and the larva then, quite colorless, was provided with otocysts but with no eyes. The shell, which was about 0.125 mm. in length, had a golden tinge and a reddish columellar region. A well-developed operculum was present (Fig. 23*c, d, e*).

Genus DOLABRIFERA

Dolabrifera olivacea Pease

Fig. 24

For a long time I sought in vain for the spawn of this mollusk, so common under loose, flat, shore rocks. Finally on February 18, 1922, an animal that was kept in a glass jar laid a peculiar, flat egg ribbon.

Later in the season—on May 25—I found, on the underside of a number of concrete slabs to which the mollusks were clinging, many of their ribbons. This egg structure is easily overlooked as it is clear and colorless—a flat band with the flat side attached to the smooth surface of a rock or other object, and spread out so as to cover a surface of 5 or more square centimeters. The ribbon rarely overlapped, but was often spread out so neatly that it formed a series of slightly curved parallel rows (Fig. 24*a, b*).

I happened to observe one of the mollusks in the act of laying eggs. The ribbon passed anteriorly, from the genital pore in the dorsal

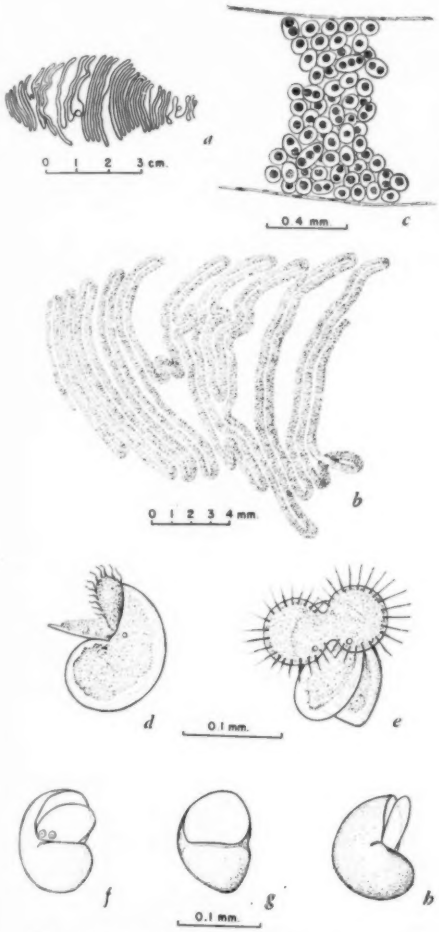

FIG. 24. *Dolabrifera olivacea* Pease. *a*, Egg ribbon; *b*, portion of egg ribbon enlarged; *c*, section of egg ribbon magnified to show arrangement of ova in egg envelopes; *d*, *e*, free-swimming veliger, lateral (*d*) and ventral (*e*) aspects; *f–h*, shell of free-swimming veliger showing operculum and otoliths.

slit, along the genital groove to the right side of the buccal disk. The mollusk then slowly moved its head from side to side, gradually backing up and carefully avoiding any overlapping of the ribbon.

As the embryos developed, the egg structures assumed a brownish or greenish color. Under magnification the egg ribbon was found to be closely packed with hyaline capsules, globular, oval, and a few oblong in form, each containing from one to three ova, usually one (Fig. 24*c*). The ova were about 0.08 mm. in diameter.

The free-swimming veliger stage was reached in 9 days. Larva and shell bore a close resemblance to those of *Tethys*. There was a well-developed, broad operculum extending well beyond the foot. No eyes were present but otocysts were. The larva had a faint yellowish or brownish tinge, while the shell was pale yellowish or golden. The length of the veliger shell was about 0.125 mm. (Fig. 24*d–h*).

Genus NOTARCHUS

Notarchus striatus Quoy and Gaimard
Fig. 25

An egg filament of *Notarchus striatus* was deposited in the laboratory, April 2, 1922. This egg structure, which was light brownish-yellow, was about 10 cm. in length, with a diameter of about 0.7 mm., and thrown into many irregular loops. A break in its length occurred in one place, as if the filament consisted of two parts (Fig. 25*a*).

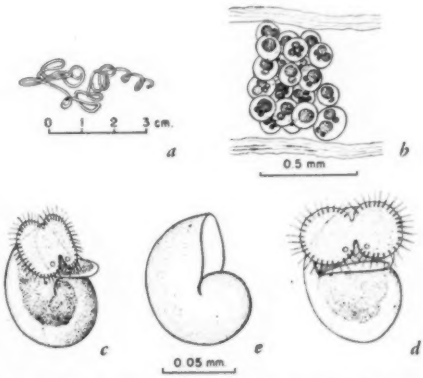

FIG. 25. *Notarchus striatus* Quoy and Gaimard. *a*, Egg filament; *b*, magnified section of filament with early cleavage stages; *c*, *d*, free-swimming veliger larva; *e*, shell of free-swimming veliger.

The parchment-like walls of the filament were rather thick and the lumen was tightly packed with ova. The ova, as in other genera of this family, were enclosed in hyaline capsules which usually contained one ovum. Sometimes there were two ova in a capsule, in which case the capsule was of an oblong form, instead of being globular or oval as were those containing only one ovum.

The diameter of the zygote was about 0.07 mm. and its first cleavage was unequal, as in *Tethys grandis*, resulting in one macromere and one micromere. The micromere divided next, equally, then the macromere, also equally, resulting in a stage of two macromeres and two micromeres. The two macromeres remained undivided, while the micromeres rapidly increased in number and formed a cap at the animal pole over the two yolk-laden macromeres at the vegetal pole (Fig. 25*b*).

The free-swimming veliger stage was reached in the short period of 6 days, when the handsome little larvae, whose shells measured but 0.09 mm. in length, emerged from the filament. The parts of the larva enclosed by the shell appeared to be straw colored, while the velum and foot were colorless; the veliger lobes were rather small and rounded, the operculum was broad and rounded and extended well beyond the foot. Otocysts were present, but no eyes. The columellar region of the shell had a light carmine tinge and the suture was of a deep reddish-brown. The rest was pellucid and colorless (Fig. 25*c, d, e*).

Family *HYDATINIDAE*

Genus HYDATINA

Hydatina amplustre (Linnaeus)

Fig. 26

On the morning of January 4, 1921, I found an egg receptacle in a glass dish with a *Hydatina amplustre*; this also served to identify several such structures that had been found close to the laboratory. The receptacle was a broad, white ribbon, intensely folded and attached to the surface of the dish with a broad adhesion disk. The ribbon had a width of about 1 centimeter and contained within its walls masses of ova enclosed in hyaline capsules. Development of the embryo was not investigated.

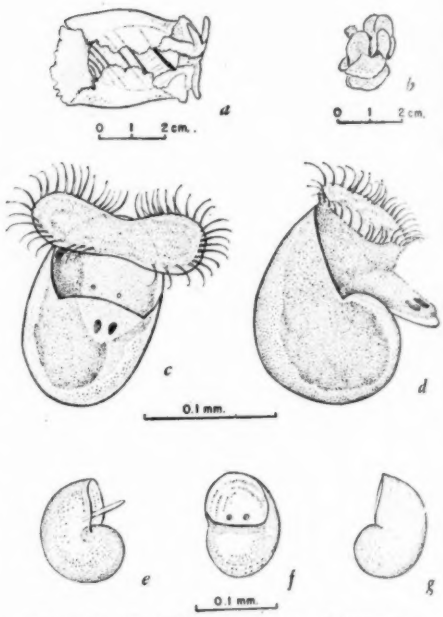

FIG. 26. *Hydatina amplustre* (Linnaeus). *a*, Animal that laid the egg structure; *b*, egg structure; *c, d*, free-swimming veliger: *c*, ventral, *d*, lateral aspects; *e–g*, shell of free-swimming veliger showing operculum and otoliths.

The free-swimming veliger possessed otocysts but not eyes. Two conspicuous elongate dark spots appeared on the ventral side of the foot near the tip, and an operculum was present on the opposite side. The clear, colorless veliger shell measured about 0.125 mm. in length (Fig. 26*a–g*).

Hydatina physis (Linnaeus)

Fig. 27

On November 16, 1922, an egg structure

attached to alga and later identified as that of *Hydatina physis* was found near the aquarium tank. It was about 25 mm. in length, half as wide, and intensely folded, much like that of *H. amplustre*. A single layer of hyaline capsules, each containing five or six embryos, lay between the walls of the structure (Fig. 27*a, b*).

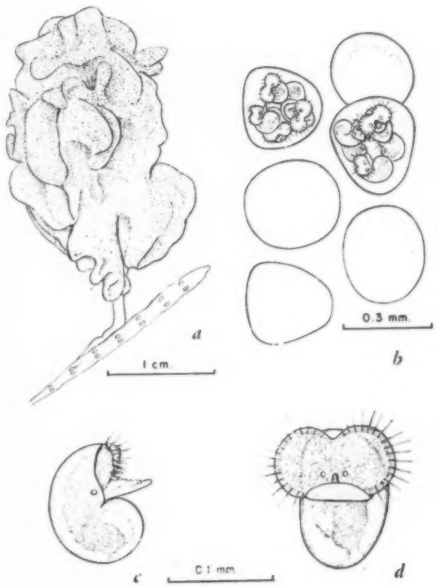

FIG. 27. *Hydatina physis* (Linnaeus). *a*, Egg structure; *b*, egg envelopes with veligers magnified; *c, d*, free-swimming veliger larva: *c*, lateral, and *d*, ventral aspects.

When the structure was obtained the embryos were far along in development. The veliger larva had a faint greenish tinge, and was a little smaller than that of *H. amplustre*. Otocysts and a prominent operculum were present. The shell, measuring 0.11 mm. in length, was colorless, like that of the preceding species. The muscle attaching the larva to the shell was clearly seen (Fig. 27*c, d*).

Family *ACTAEONIDAE*

Genus BULLINA

Bullina scabra solida Pilsbry

Fig. 28

A specimen of *Bullina scabra solida* found at Kahala reef was placed in a dish of water in the laboratory. Two days later, on the morning of March 23, 1921, the mollusk had deposited an egg filament in the dish.

The filament was a short, white, cylindrical tube, arranged in a spiral with one end attached to the bottom of the dish by means of a gelatinous material. The eggs were of varying sizes, quite numerous, and had no orderly arrangement within the structure, each being enclosed within a capsule. The animal was pure white and resembled closely *Hydatina amplustre* (Linnaeus) (Fig. 28*a, b, c*). Development was not observed.

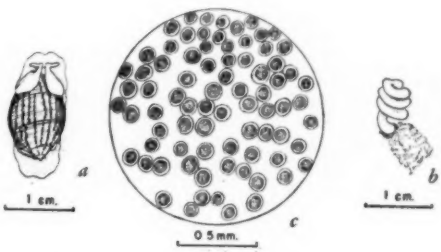

FIG. 28. *Bullina scabra solida* Pilsbry. *a*, Animal that laid the egg mass; *b*, egg filament; *c*, section of coil magnified.

Family *BULLIDAE*

Genus BULLA

Bulla sp.

Fig. 29

On November 22, 1922, two specimens of *Bulla* were brought to the laboratory from the adjacent water. An egg filament was laid by each mollusk the same day. These were comparatively thick cylindrical filaments, 3 cm. in length and 1 mm. in diameter. Each

contained a continuous string of ova wound transversely in circular loops. It could not be determined how the ova adhered to one another in a string. It seemed as if they were enclosed in an invisible gelatinous tube. Each ovum was enclosed in an oval capsule and had a diameter of about 0.06 mm. (Fig. 29*a*, *b*).

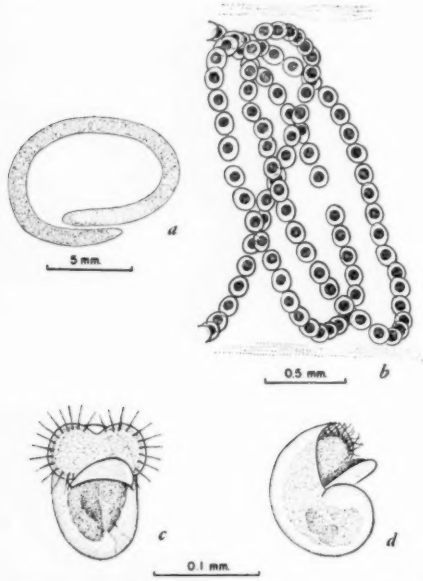

FIG. 29. *Bulla* sp. *a*, Egg filament; *b*, section of filament magnified to show arrangement of ova; *c*, *d*, free-swimming veliger larva: *c*, ventral, and *d*, partly lateral aspects.

The development of the zygotes was exceedingly rapid, the free-swimming veliger stage being attained in 4 days. The larvae and shells were colorless and neither eyes nor otocysts were present (Fig. 29*c*, *d*).

Family *AKERIDAE*

Genus HAMINOEA

Haminoea crocata Pease

Fig. 30

On March 27, 1923, several specimens of *Haminoea crocata* were brought to the laboratory from Waianae beach. Several egg filaments were laid by these animals. These filaments resembled those of the *Bulla* in their external characters as well as in the arrangement of the ova. The wall of the filament was thicker than in that of *Bulla* and each ovum was enclosed in a spherical capsule, instead of one of oval form as in *Bulla*. The diameter of the ovum was about 0.08 mm. The filament was about 4 cm. in length and about 5 mm. in diameter (Fig. 30*a*, *b*).

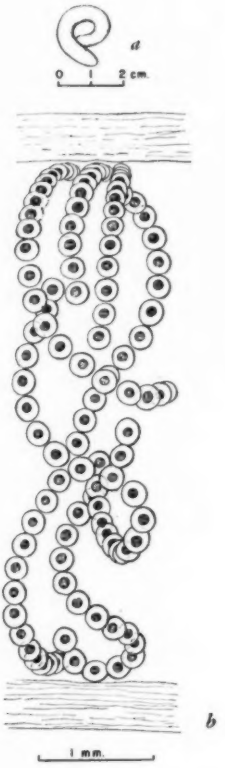

FIG. 30. *Haminoea crocata* Pease. *a*, Egg filament; *b*, section of filament magnified to show arrangement of ova.

Family *SCAPHANDRIDAE*

Genus ATYS

Atys semistriatus Pease

Fig. 31

On August 22, 1921, an egg mass was laid in the laboratory by a specimen of *Atys semistriatus* which had been found near-by.

The egg structure consisted of a globular mass of a soft, clear, gelatinous matrix, about 18 mm. in diameter, in which a thousand or more purple ova were imbedded in a spherical mass and surrounded by a thin layer of the matrix. Each ovum was enclosed in an oval hyaline capsule whose greatest diameter was about 0.2 mm.; the ovum measured about 0.09 mm. (Fig. 31*a, b*).

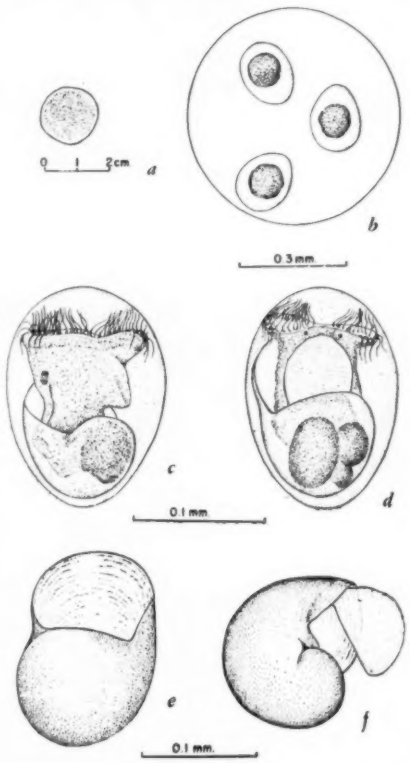

FIG. 31. *Atys semistriata* Pease. *a*, Egg mass; *b*, ova within hyaline capsules, magnified; *c, d*, veliger stage before hatching; *e, f*, shell of veliger larva with operculum.

Segmentation seemed very rapid, for the eggs, laid in the morning, were found to have attained a many-celled stage in the afternoon. Three macromeres were present at the vegetal pole, and the animal pole was capped with micromeres. About 24 hours later the embryos had become whirling ciliated gastrulas or trochophores.

The embryos did not reach their free-swimming stage, all dying within the matrix, but they reached an advanced veliger stage after 4 days' incubation. The velum was large with long cilia, the foot rather short and broad with a broad, triangular operculum. A rather ample, colorless, and transparent shell enclosed the visceral portion of the larva. A large purplish-red digestive gland could be seen in the region of the stomach, near which a well-defined intestine ran out to the anus beyond the margin of the shell. The eyes consisted of small pigment specks. Otocysts were not seen (Fig. 31*c–f*).

Family *UMBRACULIDAE*

Genus UMBRACULUM

Umbraculum sinicum (Gmelin)

Fig. 32

A specimen of *Umbraculum sinicum*, found near Waialua, Oahu, was brought to the laboratory. On the morning of June 25, 1921, a pink, garland-like egg structure was seen projecting from under its foot.

This structure consisted of a thin ribbon, 15 mm. in width, intensely folded upon itself and attached to the rock by one edge. It was wound three and one-half times around and measured about 12 cm. in diameter (Fig. 32*a*).

The ribbon was closely packed with globular capsules forming one or two layers. These capsules were quite uniform in size, 0.5 mm. in diameter, and each contained about 30 ova. A conservative estimate of the

number of ova contained in the whole structure gave the figure of 10,206,000 (Fig. 32*b*).

When examined in the morning of the day on which they were found the ova showed no signs of segmentation, but in the afternoon two- and four-cell stages were seen in many capsules, although many of the ova were still unsegmented. Adjoining capsules showed different stages of development, but the embryos in each capsule were usually of the same stage. The ovum was about 0.08 mm. in diameter and the first and second divisions resulted in blastomeres of nearly equal sizes (Fig. 32*c, d, e*). Succeeding stages of cleavage were not observed, but after the third day of incubation when the embryos had developed minute cilia, movement could be noticed. At the fourth day they showed high activity and the shell was apparently in the process of formation. A large, very conspicuous brown spot had now developed, usually on the right side of the body. After the sixth day of incubation the veliger lobes grew out and the shell covered the body. Neither eyes nor otocysts could be distinguished at this stage.

On the tenth day of incubation a large number of embryos launched upon their free-swimming larval existence. Otocysts, but no eyes, were present, as was a large operculum projecting beyond the tip of the foot and curving upward laterally. The shell was plain, colorless, and translucent (Fig. 32*f, g*).

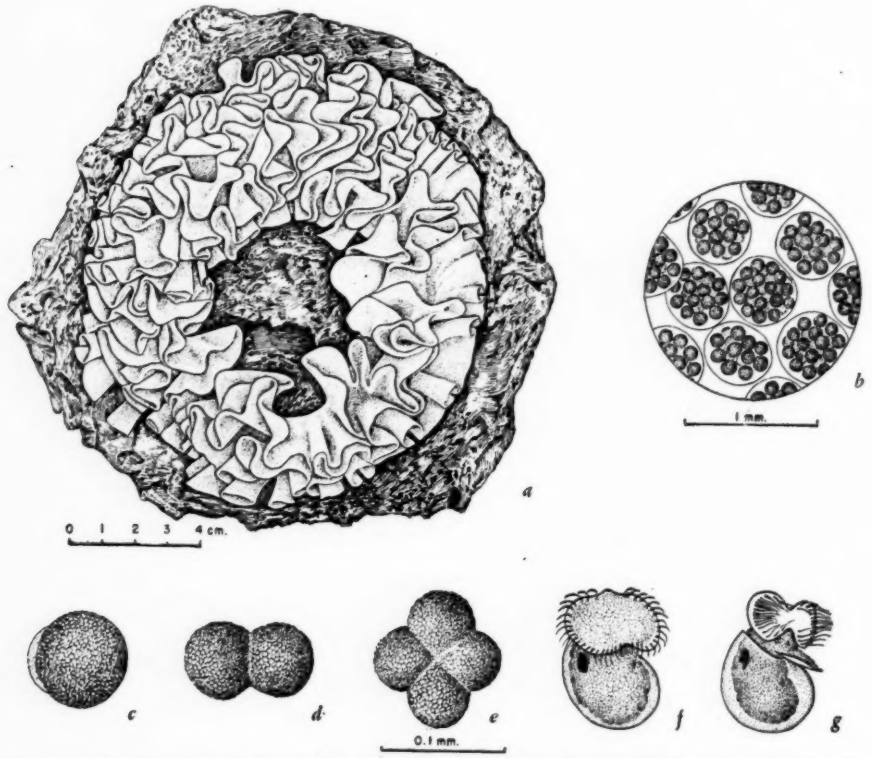

FIG. 32. *Umbraculum sinicum* (Gmelin). *a*, Egg ribbon; *b*, magnified section showing hyaline capsules with ova; *c–e*, cleavage stages; *f*, early veliger; *g*, free-swimming veliger larva.

Family *PLEUROBRANCHIDAE*

Genus PLEUROBRANCHUS

Pleurobranchus sp.

Fig. 33

On July 25, 1922, a small species of *Pleurobranchus* was found on the windward side of Moku O Loe, Kaneohe Bay, and brought to the laboratory. An egg filament, which for the size of the animal seemed very large, was laid by this mollusk. It was about 18 cm. in length with a diameter of about 4 mm. It was white and transparent and contained what appeared to be a continuous thick-walled tube wound circularly with the filaments in close contact with one another. A single layer of ova, each ovum measuring about 0.08 mm. in diameter and enclosed by a spherical capsule, lay closely packed within this inner tube (Fig. 33*a, b*).

The embryos attained their free-swimming larval stage in 6 days, at which time they had a pair of large, rounded, colorless veliger lobes with conspicuous eye spots, a pointed foot without a visible operculum, otocysts, and a large black pigment spot located near the left side. The viscera were pale greenish-yellow. The shell, which measured 0.125 mm. in length, was clear and colorless (Fig. 33*c–g*).

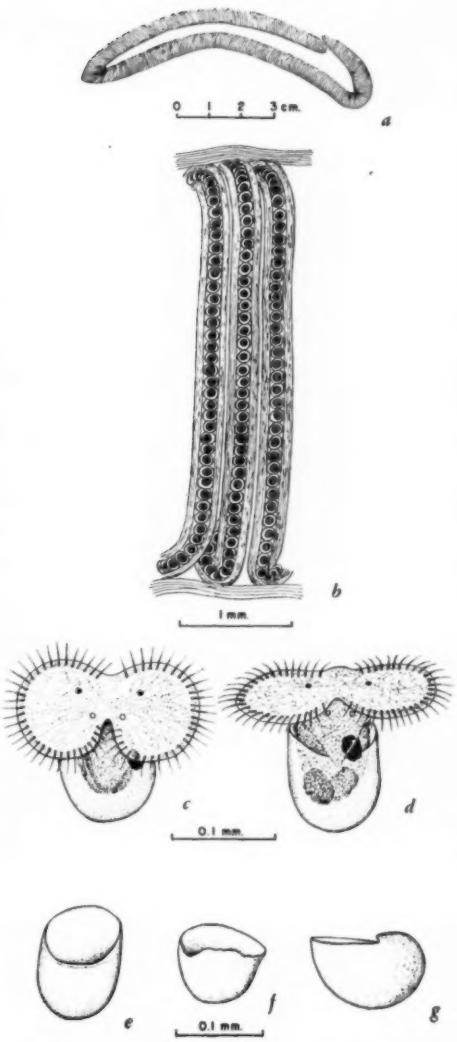

FIG. 33. *Pleurobranchus* sp. *a*, Egg filament; *b*, magnified section of filament showing circularly arranged tubes containing ova; *c, d*, free-swimming veligers; *e–g*, shells of free-swimming veligers.

Suborder ASCOGLOSSA

Family *PLACOBRANCHIDAE*

Genus PLACOBRANCHUS

Placobranchus sp.

Fig. 34

A large number of *Placobranchus* sp. was brought in from Molokai in late February, 1923, and kept in the living state in the laboratory for several months. None of these laid eggs. But a specimen found near the Elk's Club, Waikiki, during March, 1923, deposited a white cylindrical filament, about 19 mm. in length and nearly 1.5 mm. in diameter, which tapered to a point at each end. At the middle of the filament, the ova lay 9 or 10 abreast in cross section; each was enclosed in a globular capsule of about 0.16 mm. in diameter (Fig. 34*a, b*).

The first two cleavages resulted in blastomeres of equal sizes as in the typical gastropod. The embryo reached the free-swimming larval stage in 8 days. Larva and shell were clear and transparent, the operculum large and rounded. Otocysts were present but not eyes. The veliger shell measured 0.14 mm. in length (Fig. 34*c*, *d*).

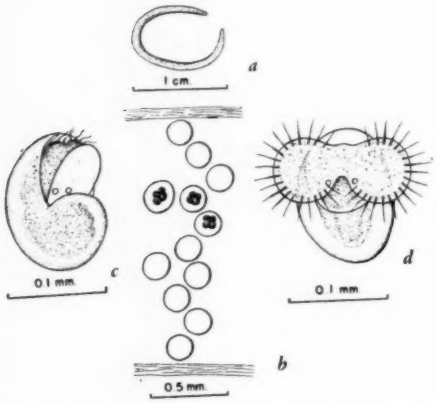

FIG. 34. *Placobranchus* sp. *a*, Egg filament; *b*, magnified section of filament showing 4-cell cleavage stage; *c*, *d*, free-swimming veliger larva.

Family *ELYSIIDAE*

Genus ELYSIA

Elysia sp.

Fig. 35

Several animals of this genus were found near the laboratory close to shore. An egg filament was deposited in the laboratory by one of them on July 5, 1923. This was a white, cylindrical, twisted filament about 25 mm. in length, closely packed with egg capsules of oval and angular shapes, each containing from two to four ova. The diameter of the ova was about 0.08 mm. (Fig. 35*a*, *b*).

The free-swimming veliger stage was reached in the short period of 5 days, when the colorless larvae in a pellucid and colorless shell emerged from the coil. The operculum extended beyond the foot; otocysts were present but not eyes (Fig. 35*c*).

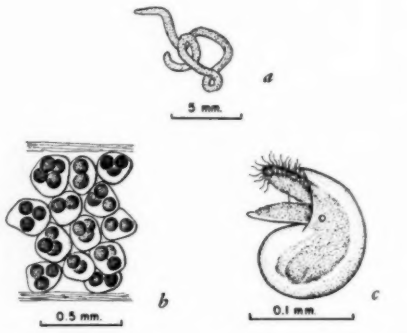

FIG. 35. *Elysia* sp. *a*, Egg filament; *b*, magnified section of filament showing arrangement of ova and hyaline capsules; *c*, free-swimming veliger larva in lateral aspect.

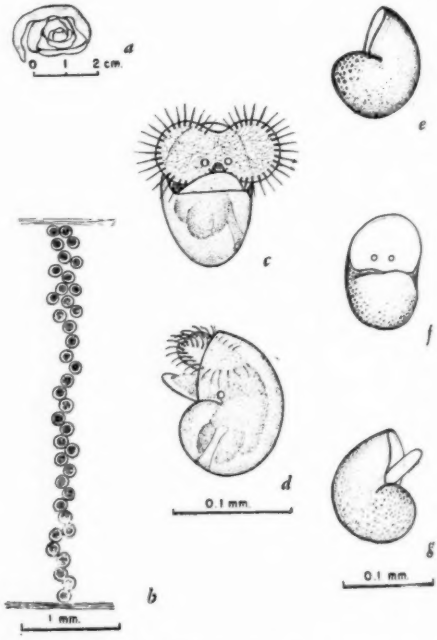

FIG. 36. *Cryptodoris* sp. *a*, Egg ribbon; *b*, magnified section of ribbon showing arrangement of ova; *c*, *d*, free-swimming veliger larva: *c*, ventral, and *d*, lateral aspects; *e–g*, shell of free-swimming veliger larva with operculum and otocysts.

Suborder NUDIBRANCHIATA
Family *DORIDIDAE*

Genus CRYPTODORIS

Cryptodoris sp.
Fig. 36

During the night of December 10, 1922, an egg ribbon was deposited in the laboratory by an animal of the genus *Cryptodoris*. This was a bright yellow ribbon of three volutions. It was about 4 mm. in width and filled with globular egg capsules, each containing an ovum. There were about 30 ova abreast in cross section. The ova were about 0.06 mm. in diameter (Fig. 36*a, b*).

As the embryos developed, the ribbon turned bright copper color and the free-swimming veliger stage was attained in about 10 days. The shell at this stage was about 0.12 mm. in length and of a bright copper color on the apical side of the columella. The veliger lobes were round with long cilia and the operculum prominent. No eyes were present but otocysts were. A larval muscle was clearly seen (Fig. 36*c–g*).

Genus GLOSSODORIS

Glossodoris sp.
Fig. 37

In March, 1923, two animals of this genus were brought to the laboratory from Waianae. An egg ribbon was deposited by one of them during the night of March 17, 1923. This consisted of a flat white band about 4 mm. in length and of one volution. About 10 ova were seen abreast in cross section, each enclosed in a spherical capsule about 0.14 mm. in diameter (Fig. 37*a, b*).

Family *HEXABRANCHIDAE*

Genus HEXABRANCHUS

Hexabranchus sp.
Fig. 38

On May 21, 1923, an egg structure was deposited in the laboratory by this beautiful nudibranch, several specimens of which had been kept living for months in aquarium jars.

A few days after the first egg structure was found, a second and larger one with one volution more than the first was deposited by the mollusk. A study was made of the first structure. This was a bright scarlet to orange,

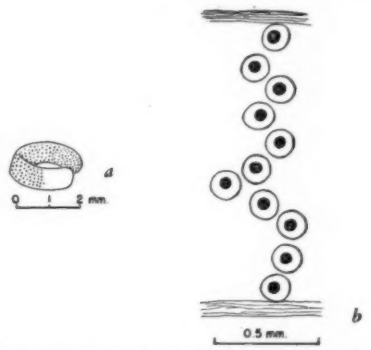

FIG. 37. *Glossodoris* sp. *a*, Egg ribbon; *b*, magnified section of ribbon showing arrangement of ova.

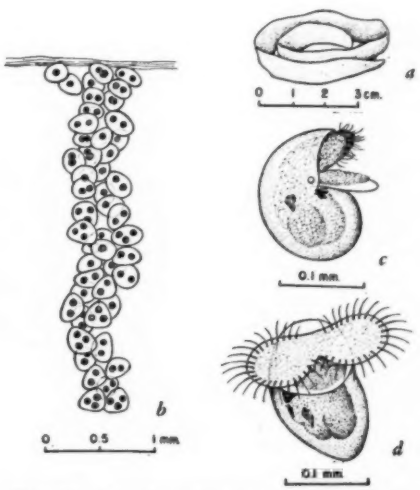

FIG. 38. *Hexabranchus* sp. *a*, Egg ribbon; *b*, magnified section of ribbon showing arrangement of hyaline capsules and ova; *c, d*, free-swimming veliger larva: *c*, lateral, and *d*, ventral aspects.

flat ribbon of two volutions, about 14 cm. in length and 6 mm. in width. The structure was closely packed with oval and triangular egg cases containing from one to three ova each. The ova were about 0.06 mm. in diameter (Fig. 38*a, b*).

The free-swimming stage was attained in 9 days, when a pale brownish larva emerged. On the right side of the body of the larva was an irregular black pigment spot and near it another of dark orange. Otocysts were present, but not eyes. A broad operculum and a clear and pellucid shell were present (Fig. 38*c, d*).

Family *AEOLIDIIDAE*

Genus AEOLIDIA

Aeolidia sp.

Fig. 39

During the month of April, 1922, a number of egg structures were deposited on a rock in the laboratory by a species of *Aeolidia.* They were flat, bright yellow ribbons about 18 mm. long and 2 mm. wide, of one volutions which was so close that the inner margins, by which the mass was attached, almost touched (Fig. 39*a, b*). The ova were strung out in single rows within transverse gelatinous tubes which radiated from the inner margin of the ribbon. A row contained an average of 15 ova. The spaces between the transverse tubes toward the outer margin also contained ova (Fig. 39*c*). The ova, which measured about 0.17 mm. in diameter, were contained singly in oval capsules.

This is the most prolific mollusk in point of numbers of egg structures yet observed. Nine ribbons were deposited by the same animal within 12 days, one each day for several days. Two more mollusks of this species were brought in from near the Elk's Club, Waikiki. Both animals were on a living coral head, *Porites compressa,* to which were attached half a dozen or more egg ribbons. During 10 days of captivity the number of ribbons deposited by them had increased to 30. The ribbons were all of a very pale yellow and nearly all of them were larger than those of the first lot, most of them being twice as great in diameter.

The eggs of all the ribbons seemed to develop and the free-swimming stage was reached in 6 days. The eyespots in this larva were large and prominent, as were foot and operculum. The viscera had a marked yellowish tinge, but the foot and velum were almost colorless. The shell, measuring 0.225 mm. in length, is pellucid and colorless (Fig. 39*e, f*).

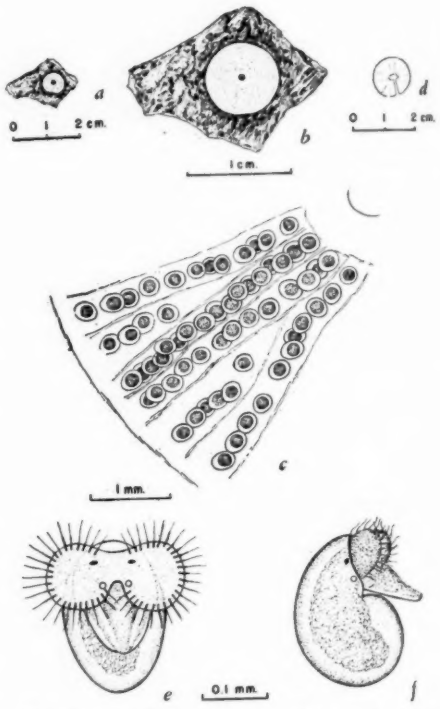

FIG. 39. *Aeolidia* sp. *a,* Egg ribbon; *b,* ribbon enlarged; *c,* magnified section of ribbon showing arrangement of ova; *d,* egg ribbon laid by another individual; *e, f,* free-swimming veliger larva: *e,* ventral, and *f,* lateral aspects.

Family *FIMBRIIDAE*

Genus MELIBE

Melibe pilosa Pease

Fig. 40

Early in February, 1922, some egg structures were deposited in the laboratory by specimens of *Melibe pilosa* found close to the laboratory pier. The egg structure consisted of a very thin, broad, white ribbon, greatly folded, and spirally wound several turns, united by the inner edges, by which it was attached to a rock or other object (Fig. 40*a*). Transversely arranged within the capsular wall, and closely filling the space, was a cylindrical tube packed with egg cases arranged in a single row. These egg cases, or hyaline envelopes, had the shape of a hen's egg and measured about 0.17 mm. by 0.25 mm. Each case contained one ovum which had an average diameter of 0.125 mm. (Fig. 40*b*).

Development of the embryo was not investigated, but a study of the veliger shell was made. This was elongate, pellucid and colorless, about 0.2 mm. in length (Fig. 40*c*, *d*).

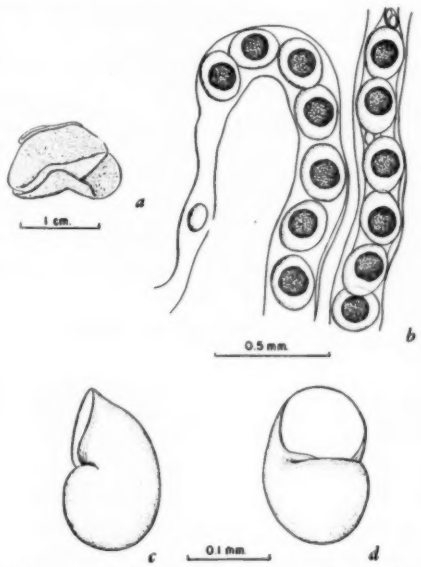

FIG. 40. *Melibe pilosa* Pease. *a*, Egg ribbon; *b*, magnified section of ribbon showing ova in hyaline capsules contained in tubes; *c*, *d*, shell of free-swimming veliger.

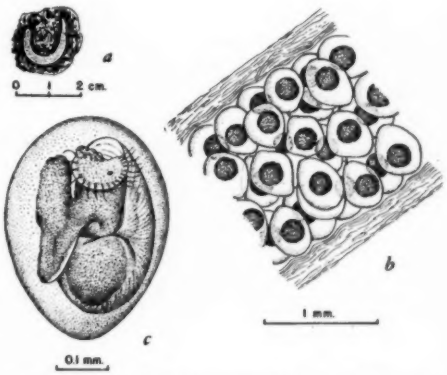

FIG. 41. *Siphonaria normalis omara* Reeve. *a*, Egg ribbon; *b*, magnified section of ribbon showing compact masses of hyaline capsules with ova; *c*, unhatched veliger stage.

Order PULMONATA

Family *SIPHONARIIDAE*

Genus SIPHONARIA

Siphonaria normalis omara Reeve

Fig. 41

On September 9, 1923, a specimen of *Siphonaria* deposited an egg structure in the laboratory, several of the animals having been brought in from the near-by sea wall. The egg structure was a somewhat thickened colorless ribbon, arranged in a half circle which measured about 3 cm. in length and 2 mm. in width. The walls of the ribbon were very thick and fibrous, and the eggs were closely packed in two layers. A rather ovoid hyaline envelope surrounded each ovum. This envelope measured about 0.485 mm. in length and 0.34 mm. in width; the diameter of the ova was about 0.19 mm. (Fig. 41*a*, *b*).

Steps in development were not observed, but a study of the embryo when it had reached the veliger stage was made. The color of the animal was pale greenish, while that of the

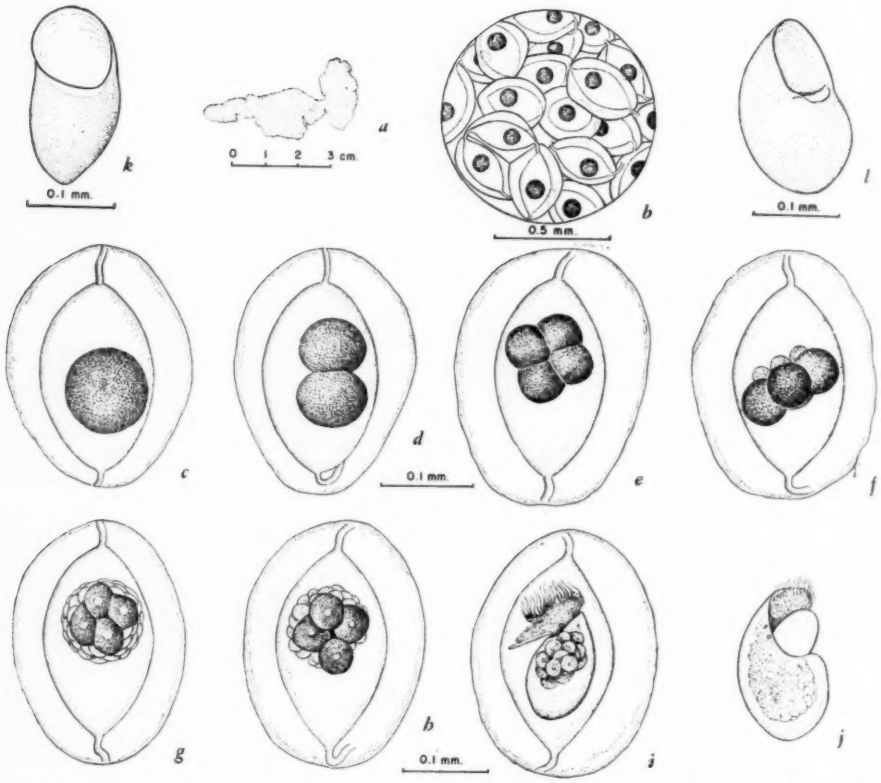

FIG. 42. *Peronia* sp. *a*, Egg structure; *b*, magnified section of egg structure showing a double capsular enclosure for ova; *c–g*, cleavage stages; *h*, gastrula ?; *i*, early veliger with extremely large endodermal cells; *j*, free-swimming veliger; *k*, *l*, shell of free-swimming veliger.

shell was brown. Eyes were present. The foot was large with a conspicuous operculum. The shell was about 0.33 mm. in length (Fig. 41*c*). The embryos all died, so the free-swimming stage was not observed.

Family *ONCHIDIIDAE*

Genus PERONIA

Peronia sp.

Fig. 42

Early in September, 1921, a number of specimens of *Peronia* were gathered from crevices in the sea wall near the laboratory. These were placed in a jar with running water, from which they soon escaped, being air-breathers, and scattered all over the aquarium tables. Some crawled into dark, wet corners of wooden boxes, where they seemed to thrive. Some lived thus for months in the laboratory. It is obvious that this mollusk cannot live under water, while, on the other hand, it needs to be kept wet constantly with sea water. It has been found at Kaena Point and Black Point on the shore rocks above high tide level and where only the spray could reach it. A large number of these mollusks were found at Kawailoa, Oahu, during June.

Eggs were deposited in the laboratory by one of these animals on September 3, 1921. Since that time they have often been obtained from other individuals. The egg structure was a lemon-yellow, tough, gelatinous mass with irregular outlines, pasted flatly onto any surface. The ova were closely packed throughout the whole structure and each was enclosed within a double capsule. The diameter of the ovum was about 0.08 mm. The lesser diameter of the inner capsule, which was of a regular oval or oblong form, was 0.14 mm., its greater diameter being 0.22 mm. The lesser diameter of the outer capsule, which was of an irregular oval or somewhat baggy shape, was 0.2 mm.; its greater diameter was about 0.28 mm.

The relations of the capsules to one another appeared to be as follows: from each end of the inner capsule sprang a slender tube or thread which united with another inner capsule, penetrating the outer capsule in doing so, forming thus a continuous, closely united string of egg capsules thrown promiscuously together (Fig. 42*a, b*).

Cleavage of the zygotes commenced the same day they were laid, the 4-cell stage being reached during the afternoon. The first two divisions were equal and the third resulted in four micromeres at the animal pole of the macromeres; hence it was typical of gastropod cleavage (Fig. 42*c–f*).

A many-celled, or morula, stage was reached after 24 hours. The four undivided macromeres showed up distinctly at the vegetal pole, their nuclei appearing as clear globules. From the animal pole numerous micromeres extended beyond the equator. Soon a contraction of each of the four undivided macromeres took place, rounding off their former angular outlines and leaving an opening between them (the gastropore?) at the vegetal pole. Cleavage of the macromeres seemed greatly retarded, probably due to the obstruction of the yolk. This is typical epibolic gastrulation (Fig. 42*g, h*).

The extremely slow division of the macromeres, or endodermal cells, remained a characteristic feature of the development of this mollusk. Even when the veliger stage was reached, these cells appeared as a large cluster, each with a distinct, rounded outline and a clear central nucleus (Fig. 42*i*).

The free-swimming stage was attained after 9 days of incubation, when a veliger larva appeared within an elongate, clear, colorless shell which was nearly bilaterally symmetrical. The foot bore a broad, anteriorly rounded operculum. Eyes, as well as otocysts, were present. The endodermal cells, still large and conspicuous, were of a bright yellow or brassy color (Fig. 42*j, k, l*).

CONCLUSIONS

Pelagic Stage and Distribution

Of all the species studied—those included in this paper and others to be reported upon later—41 attained the veliger stage. Of these, 40 were found to have a pelagic stage, thus giving the high figure of 97.5 per cent pelagic or free-swimming larvae.

This seems remarkable in view of the fact that Thorson (1940) reports 75 per cent from the Iranian Gulf as the highest percentage in a list prepared by him, while next highest he quotes Risbec from New Caledonia with 57 per cent. He shows a general increase in pelagic larvae from the colder to the warmer waters, beginning with none in East Greenland and ending with 75 per cent for the Iranian Gulf.

It appears that temperature is of much importance in determining the pelagic stage, but there seem to be other controlling factors also. When the isolation of the Hawaiian Islands caused by their vast ocean barriers is considered, it may be inferred that its molluscan population must have depended upon a pelagic or free-swimming stage of sufficient duration to enable the larvae to be carried by currents from islands in the Pacific support-

ing a gastropod fauna similar to the one of Hawaii. Such faunas are found in Micronesia. We may then postulate that ocean currents from that region were the source of distribution of the marine gastropods of Hawaii. The veliger larva could be carried east by the North Equatorial Current, which, along its course, might yield parts of its planktonic cargo to the westward-flowing Japan Current to be carried by it to the Hawaiian Archipelago. If this be the chief, or only, method of deriving our marine gastropod fauna, we must at once recognize the importance of a long free-swimming existence to the successful migration over vast ocean barriers.

Phylogenetic Significance of Veliger Shell

The great dissimilarity between the veliger larva and the adult gastropod may have its explanation on the basis of adaptation on the one hand and heredity on the other. To structures that have developed as adaptive measures in the larva is applied the term cenogenetic in contradistinction to the term palingenetic, which deals with characters of ancestral significance, thus throwing light upon the evolutionary history of the organism.

The ciliated veliger lobes by means of which the larva leads its pelagic existence appear important to the distribution of numerous species and might therefore be classed as an adaptation. We can, however, conceive of a minute gastropod ancestor, which, like the wheel animalcule (Rotifera), was provided with ciliated lobes that served both for locomotion and food getting before it developed its protective shell. Concerning the veliger shell it will be noted that it was present in the opisthobranch larva as well as in that of the prosobranch, even in groups where it is entirely lacking in the adult animal. In addition to the veliger shell an operculum was found in all but two species, *Conus hebraeus* and *Pleurobranchus* sp. I have failed to see any service of the operculum to the veliger larva. During the active existence of the larva, the foot with its operculum was fully extended, and only when a larva sank to the bottom to die was the operculum seen to close the aperture to the shell.

Veliger larva and shell both show a close approach to a bilateral symmetry, which in later development is lost by coil formations. It appears that both the veliger larva and the shell with the operculum have a palingenetic significance in which the swimming apparatus, the veliger lobes, have been retained owing to their functional value, coming to overlap in time, as it were, a later ancestral structure, the shell.

Supportive evidence for such a contention may be found in a comparison of the veliger shell with some of the fossil gastropods of the early Paleozoic era, Cambrian and Ordovician, which show simple shells of bilateral symmetry and from which might be derived the divergent groups, viz., the coiled snail on the one hand and the naked slug on the other.

One may readily observe a similarity in the structure of spawn as well as in larval peculiarity in species of the same genus and more so, perhaps, if the species are closely related. Such a condition may then parallel to a large extent the taxonomic position assigned to the adult forms and, therefore, be of taxonomic value.

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Vespoidea of Micronesia. 3[1]

KEIZÔ YASUMATSU[2]

IN 1938 Professor Teiso Esaki recorded the occurrence of a mutillid wasp in Micronesia for the first time. This handsome mutillid was identified by him as *Timulla (Trogaspidia) albertisi* (André, 1896), although he felt some suspicion with respect to the identity of certain details of the pubescence. In the spring of 1949 Professor Esaki requested me to re-examine this mutillid specimen. After a careful study of the specimen, as well as of the descriptions of some related species, I came to the conclusion that the specimen represents a new species, as pointed out by Dr. Krombein (Hawaii. Ent. Soc., Proc. 13, 1949).

Timulla (Trogaspidia) esakii sp. nov.

1938 *Timulla (Trogaspidia) albertisi* Esaki (*nec* André), *Annot. Zool. Jap.* 17: 431–432, ♀.

1949 *Timulla* sp., Krombein, *Hawaii. Ent. Soc., Proc.* 13: 369, 375–376.

Female. 10.5 mm. long. Head, thorax, and abdomen entirely black. Median portion of mandibles, antennal tubercles, and apex of antennal scapes ferruginous. Front clothed with sparse, erect, pale pubescence and somewhat dense, recumbent, ferruginous pubescence. Vertex covered with thick, appressed, pale or somewhat ferruginous pubescence, but not distinctly "échancrée en arc en avant" as in *albertisi*. Genae with somewhat thick, recumbent, pale pubescence. Mandibles slender, edentate at apex and with a small tooth on inner margin near apex. Clypeus elevated posteriorly, elevated margin arcuate and with a very small tubercle just at the middle of the margin, median longitudinal line of elevated area ridged; anterior margin of clypeus straight. Antennal scape almost impunctate; third antennal segment about twice as long as fourth. Antennal scrobes carinate above. Malar space about as long as wide. Front, vertex, and genae with moderate, dense, confluent punctures. Apical half of malar space almost impunctate, but basal half minutely wrinkled. Relative width of head and thorax (mesonotum) about 37:32. Dorsum of thorax clothed with sparse, erect, pale pubescence and sparse, recumbent, somewhat ferruginous pubescence. Pale pubescence on dorsum of anterior portion of pronotum thick and erect. Posterior face of propodeum with somewhat dense, long, erect, pale pubescence. Pleural area with pale or whitish micropubescence. Dorsum of thorax with moderately large, dense, confluent punctures; humeral angles angulate but inconspicuous; pronotum slightly wider posteriorly than anteriorly; mesonotum only faintly narrower than pronotum; lateral margins parallel and crenulate; scutellar scale present, distinct and slightly raised; lateral margins of posterior face of propodeum denticulate. Anterior margin of propleurae defined by distinct carina; all of pleural areas, including sides of propodeum, impunctate. Abdominal tergites II, IV, and V covered with ferruginous black, velvety pubescence; laterobasal areas of second tergite and basal and apical margins of fourth and fifth tergites without such velvety pubescence; second tergite with a pair of large, subcircular, anterior spots separated by about their own transverse diameter; third tergite

[1]Results of Professor T. Esaki's Micronesia Expeditions, 1936–1940, No. 79.

[2]Entomological Laboratory, Faculty of Agriculture, Kyushu University, Fukuoka, Japan. Manuscript received July 21, 1949.

with a broad, complete band of dense, appressed, golden pubescence. Pubescence on posterior margin of second tergite somewhat ferruginous at middle and pale laterally. A very small tuft-like golden pubescence is recognizable at middle of posterior margin of second tergite. First tergite and anterior portion of second covered with rather dense, erect, long, pale pubescence. Pygidium with dense, erect, long, pale pubescence only at sides. Posterior margin of second to fourth sternites with rather dense, erect, long, pale pubescence. First tergite with dense, moderate punctures, posteriorly the punctures close and confluent; second tergite with moderate, well-separated punctures. Tergites III to V with small, well-separated punctures. Pygidium minutely, longitudinally striate except apically and with close, small, confluent punctures at sides. First sternite with a prominent, median, longitudinal carina, in profile appearing roundly emarginate; second sternite with sparse, moderate punctures except the posterior margin with small, close punctures; sternites III to V with sparse, moderately small punctures, denser at the posterior margin of each; hypopygium with moderately small, close punctures. Legs entirely black, sparsely covered with pale pubescence; calcaria pale.

Holotype: ♀, Palau Islands—Ashiasu, Peliliou Island, 23, II, 1938, Professor Esaki leg., preserved in the collection of the Entomological Laboratory, Kyushu University.

Habitat: Micronesia—Palau Islands.

This new species is closely related to *Timulla (Trogaspidia) albertisi* (André, 1896) from New Guinea, but the latter is quite distinct from this species in the following points: "Tête avec des soies noires éparses sur le front; vertex largement recouvert d'une bande de pubescence fine, serée, d'un jaune d'or soyeux, échancrée en arc en avant. Thorax hérissé de soies noires sur le dos . . . et recouvert sur les flancs d'une pubescence jaunâtre . . ." (E. André, 1896, Études sur les Mutillides existant dans les collections du Musée Civique de Gênes. *Ann. Mus. Civ. Stor. Nat. Genova* II, 17: 70–71).

This species is known at present only from the unique female described above. It is named in honor of Professor Esaki of the Kyushu University, who first discovered the mutillid wasp in Micronesia.

I wish to express my sincere thanks to Professor Esaki for his generosity in placing the material at my disposal.

Contributions to the Knowledge of the Pacific Species of *Antithamnion* and Related Algae[1]

JUN TOKIDA AND TADAAKI INABA[2]

THE JUNIOR AUTHOR, T. Inaba, expert of the Fisheries Department of Fukui prefectural government, was able to make collections of marine algae along the coast of Bōsō Peninsula lying southeast of Tokyo Bay, during the time he was engaged as a teacher in the Awa Suisan-Gakkō (School of Fisheries) in Tateyama City, Chiba prefecture. This is a most interesting coast for phycologists, offering many kinds of temperate-zone seaweeds, and, of course, has already been frequently botanized by many other persons. Nevertheless, further effort in searching there for new or rare species seems to be quite promising in view of the fruitfulness of the junior author's collections, especially those made in the spring of 1944. Partial results of our studies on the species of *Antithamnion* and its allied genera which were thus discovered are reported here.

The text figures 1*a*, 1*b*, 4, 5*a*, 5*b*, and 10*a* are reproduced from the drawings by Inaba, while the rest are from those of Tokida. Figures 6 and 8 are reproduced from photograph negatives obtained by projecting on bromide papers with an enlarging camera the images of the specimens mounted in glycerine on a glass slide.

It will not be superfluous to give here an explanation of the technical terms used in our descriptions. By the terms "ramus" or "branch," "pinna," "pinnula," and "ramulus," we intend to express the different orders of the successive branching system in *Antithamnion* and its allied genera. The ramus, being provided with a meristem at its top, is the direct offshoot of the main axis of the frond and bears pinnae. Pinnae, in *Antithamnion*, are usually opposite or sometimes whorled offshoots on each segment of the main and branch axes, simple or divided, bearing, in the latter case, pinnulae. Pinnulae, in *Antithamnion*, are opposite, alternate, or secund on the pinnae, arising usually singly or rarely by pairs from some segments of the axis of pinnae. Ramuli are usually simple offshoots arising singly from some segments of the axis of pinnulae. By "ultimate ramuli," however, we do not always mean ramuli but sometimes mean either pinnulae or pinnae according to the extent of intricacy of the branching system.

The senior author wishes to acknowledge his indebtedness to Mme. Valerie May for her kindness in sending him a fragment of an authentic specimen of *Acrothamnion pulchellum* J. Ag., and to Dr. E. Yale Dawson of the University of Southern California for his kindness in sparing from his library valuable publications helpful for the present study.

Antithamnion basisporum Tokida and Inaba, sp. nov.

Figs. 1*a–c*; 2*a–d*

Fronde sparse ramosa et opposite pinnata; axibus principalibus inferne repentibus, rhizoidibus brevissimis et simplicibus, 16–26 μ crassis, a cellulis basalibus pinnarum emit-

[1]The expense of the present study has been partly defrayed from the subsidy granted by the Hattori Hōkō Kai, and from the fund for scientific research granted by the Ministry of Education.

[2]Botanical Laboratory, Department of Fisheries, Faculty of Agriculture, Hokkaido University, Sapporo, Japan. Manuscript received April 26, 1949.

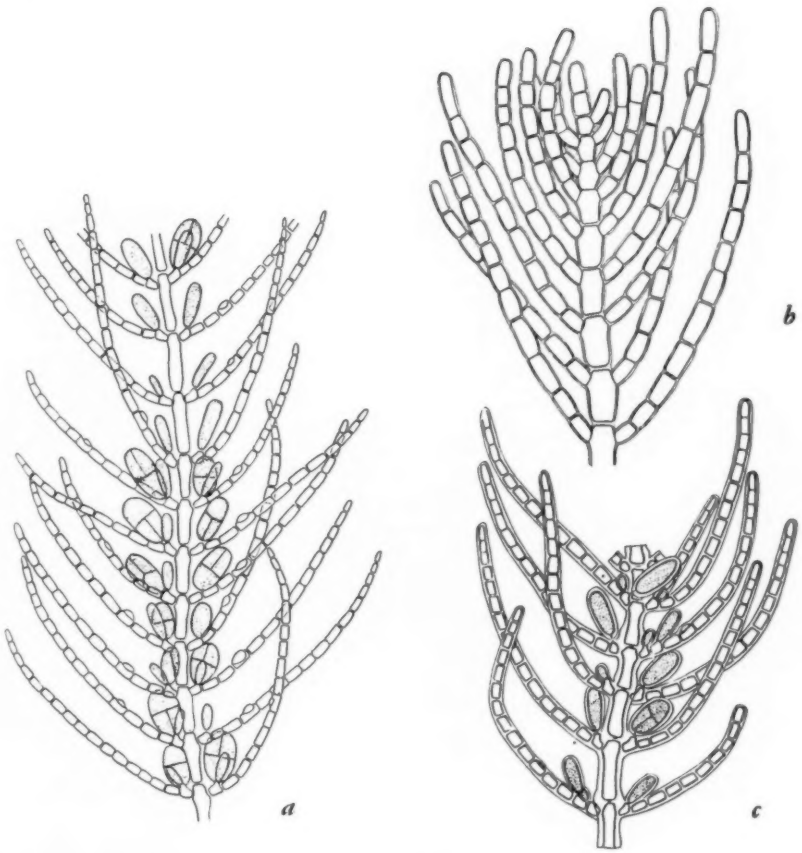

FIG. 1. *Antithamnion basisporum* Tokida and Inaba, sp. nov.: *a*, middle portion of a main branch, showing tetrasporangia and gland cells; *b*, apical portion of a main branch; *c*, part of a branch, showing that two of the pinnae bear a sporangium on each of two lowest cells, and that one pinna bears on its lowest cell a pinnula together with a sporangium. *a* and *c*, × 150; *b*, × 350.

tentibus adfixis, superne erectis et ca. 2 mm. altis; ramis in plerusque a cellulis basalibus pinnarum vel raro a cellulis axialibus ramorum ipsis emittentibus, usque ad 20–32 μ crassis, cellulis diametro 1–4-plo longioribus; pinnis simplicibus vel raro semel divisis, apice rotundatis, 7–14 (–16)-cellularibus, usque ad 14 μ crassis, cellulis diametro 1–3-plo longioribus, cellulis glandulinis supra unam cellulam lateraliter sitis ornatis; chromatophoris paucis, taeniatis; tetrasporangiis in cellulis basalibus pinnarum sessilibus, 28–38 μ × 56–64 μ, cruciatim divisis; spermatangiis et ramulis carpogonatis ignotis.

Frond sparsely branched and oppositely pinnate; main axis creeping below, attached to the substratum by means of short, simple rhizoids, 16–26 μ diam., arising from the basal cells of pinnae, erect above, ca. 2 mm. high; branches usually produced from the basal cells of pinnae or rarely from the axial cells of the main branch itself, up to 20–32 μ

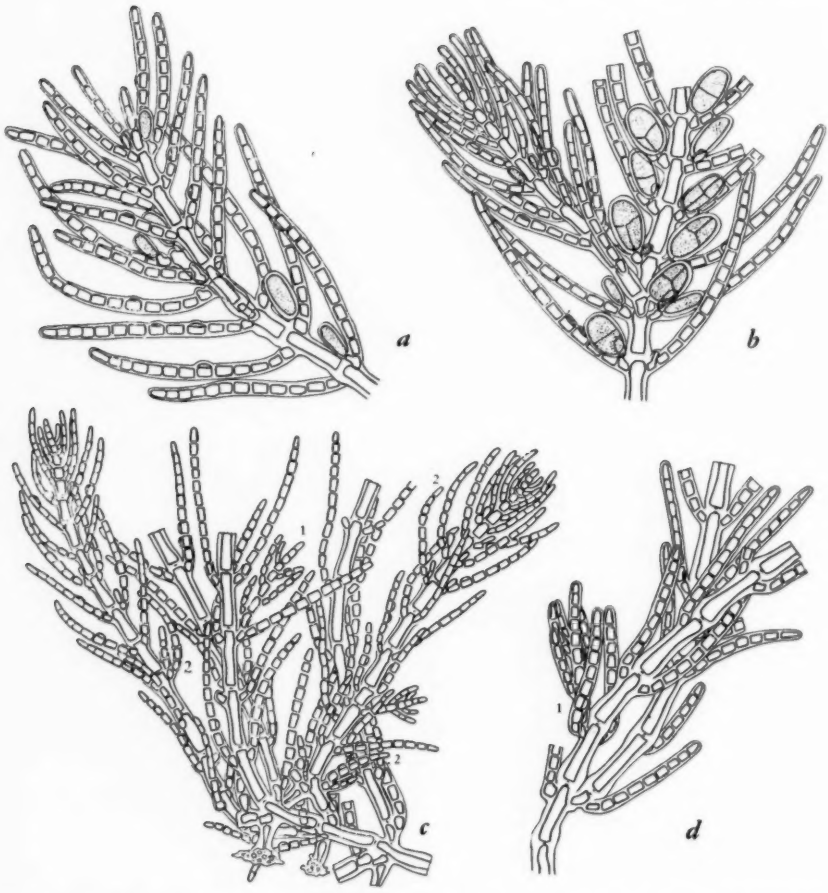

FIG. 2. *Antithamnion basisporum* Tokida and Inaba, sp. nov.: *a* and *b*, mode of branching in the upper portion of a frond; *c* and *d*, mode of branching in the lower portion of a frond and young branches arising from the lowest cell of the pinna (1); *c*, rhizoidal filaments: three pinnae which bear on their lowest cells a short pinnula (2), and the branch apices, are also shown. *a*, *b*, and *d*, × 150; *c*, × 137.

diam., with cells 1–4 diameters long; pinnae simple or rarely once divided, rounded at apices, 7–14 (–16)-celled, up to 14 μ diam., with cells 1–3 diameters long, provided with gland cells which sit singly on the upper lateral side of the cell; chromatophores a few bands; tetraspores sessile on the basal cells of pinnae, 28–38 μ × 56–64 μ, cruciately divided; sexual reproductive organs unknown.

Japanese name: NIRETSU-KASANEGUSA (nom. nov.).

Type: Growing on pebbles, Mera, Prov. Bōshū. *T. Inaba 401,* Apr. 10, 1944 (Herbarium, Dept. Fish., Hokkaido Univ.).

This species of *Antithamnion* is one of those bearing simple pinnae. It differs from many of the allied species, e.g., *A. glanduliferum* Kylin, *A. pacificum* (Harv.) Kylin, *A. Gardneri* De Toni, etc., in having one to two tetrasporangia on the lowermost cell of

the pinnae, while it resembles in this respect *A. Miharai* Tokida (Tokida, 1942: 90, text figs. 5 and 6). The last-mentioned species differs from our new species in having tetrasporangia not only on the lowermost cell but also on two succeeding cells. The most striking character of the present species seems to be that the tetrasporangia are arranged in a longitudinal row along each side of the axis of branches. The cell next to the lowermost cell of pinnae rarely bears a sporangium. In the lower part of the frond a branch is produced by the basal cell of a pinna, and sometimes it lacks an adaxial pinna on its lowermost cell, while in the upper part of the frond a branch is formed directly from the axial cell of the main branch and is provided with a short basal cell which bears no pinna but occasionally bears a sporangium. The cell next to the basal cell of a branch in the upper part of the frond sometimes lacks an adaxial pinna. The pinnae are as a rule simple, but rarely they bear a small pinnula on their lowermost cell. A pinnula of this kind is probably nothing but the beginning of a branch.

Antithamnion cristirhizophorum

Tokida and Inaba, sp. nov.
Figs. 3*a–d*, 4

Fronde ca. 5 mm. alta, sparse ramosa et opposite pinnata, repenti, rhizoidibus cristatis a cellulis basalibus pinnarum emittentibus ramis aliae algae ut *Ceramii* sp. et *Gelidii subcostati* adfixa; ramis a cellulis basalibus pinnarum emittentibus, usque ad 120–150 μ crassis, inferne cellulis diametro 1.5–3.5-plo, superne 0.5–2-plo, longioribus, cellulis apicalibus 8 μ crassis; pinnis lanceolatis, cellulis ad septa leve constrictis, cellulis basalibus subquadratis et usque ad 64 μ crassis, inferioribus diametro 1–2-plo longioribus et usque ad 80 μ crassis, apice subulatis, inferne pinnatis, superne inferiore latere pectinatis; pinnulis simplicibus vel raro semel divisis, inferne 20–52 μ crassis, cellulis diametro 1–1.5-plo longioribus, apice subulatis; cellulis glandulinis numerosis, 22–40 $\mu \times$ 15–32 μ, in pinnulis brevioribus singulatim supra cellulas tres sitis; chromatophoris numerosis, disciformibus. Fructus ignoti.

Frond ca. 5 mm. high, sparsely branched and oppositely pinnate, creeping on the branches of other algae, such as *Ceramium* sp. and *Gelidium subcostatum*, by means of crested rhizoidal filaments arising from the basal cells of pinnae; branches produced from the basal cells of pinnae, up to 120–150 μ diam., with lower cells 1.5–3.5 and upper cells 0.5–2 diam. long, and apical cells 8 μ diam.; pinnae lanceolate, slightly constricted at septa, the basal cells being subquadrate and up to 64 μ diam., lower cells being 1–2 diam. long and up to 80 μ diam., subulate at apices, pinnate below, pectinate on the lower side in the upper portion; pinnulae simple or rarely once divided, 20–52 μ diam. below, with cells 1–1.5 diam. long, subulate at apices; gland cells abundant, 22–40 $\mu \times$ 15–32 μ, sitting singly over three cells on short pinnulae; chromatophores numerous discs. Reproductive organs unknown.

Japanese name: FUSANE-KASANEGUSA (nom. nov.).

Type: Epiphytic on other algae, e.g., *Gelidium subcostatum* Okamura and *Ceramium* sp., Shirahama, Prov. Bōshū. *T. Inaba 350*, Mar. 11, 1944 (Herbarium, Dept. Fish., Hokkaido Univ.).

This species of *Antithamnion* is one of those bearing gland cells of the scaphoid type, or those resting laterally on two or three cells. The frond is repent on the thallus of other algae, such as *Gelidium subcostatum* and *Ceramium* sp., and is attached by means of short crested rhizoidal filaments arising from the lowermost cells of pinnae. The pinnae and pinnulae are lanceolate, being sharply acute at the apex, somewhat thickened in the middle portion, and slightly attenuated toward the base. The pinnulae are

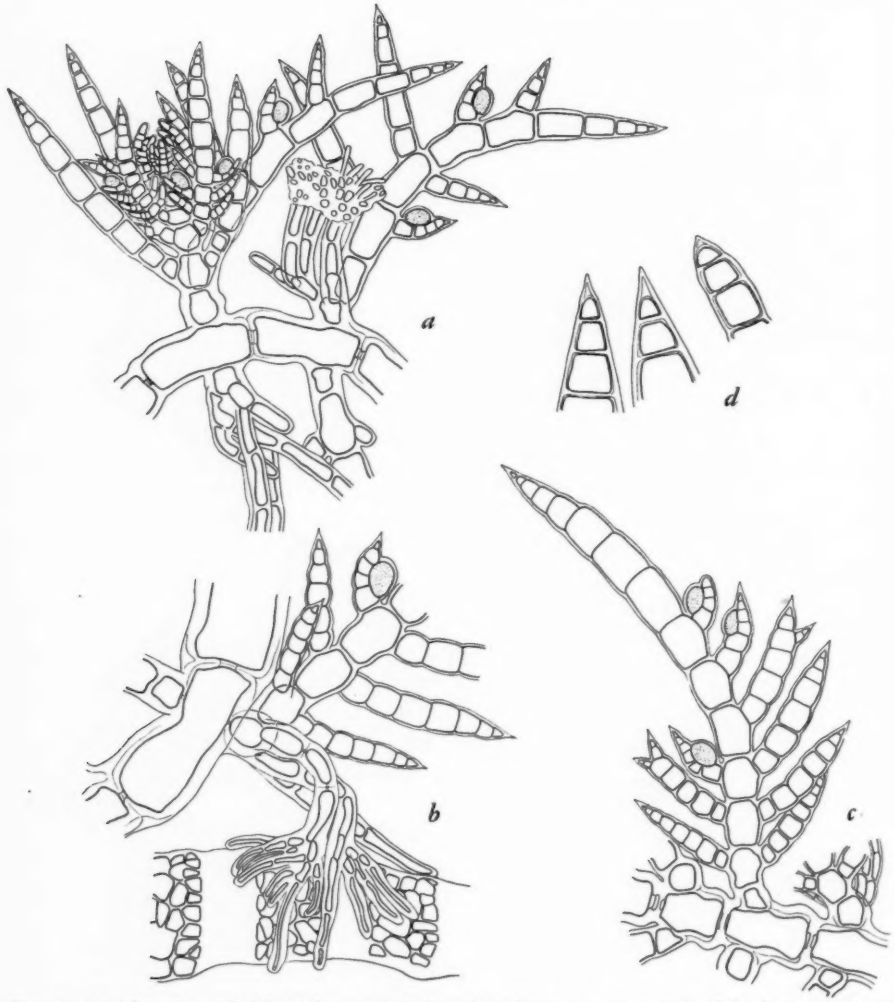

FIG. 3. *Antithamnion cristirhizophorum* Tokida and Inaba, sp. nov.: *a*, part of the lower portion of a frond, showing rhizoidal filaments, gland cells, and a young branch; *b*, the same, showing a tuft of rhizoidal filaments attached to a branch of *Ceramium* sp.; *c*, a pinna bearing nine pinnulae, two of which are once-divided pseudo-dichotomously near the tip; *d*, the tips of three ultimate ramuli. *a* and *c*, × 137; *b*, × 150; *d*, × 480.

usually simple, but rarely pseudo-dichotomously divided at their apices.

Platythamnion horridum Tokida and Inaba, sp. nov.

Figs. 5*a, b*; 6*a–d*; 7*a–d*

Fronde usque ad 2 cm. alta, subdichotome repetite ramosa, pinnis quaternis dense verticillata; pinnis lateralibus maturis brevissimis, 80–200 μ longis, ad basin 22–46 μ crassis, axibus 5–7-cellularibus, oblanceolatis, superiore latere pectinatis, in inferiore parte binis seriebus pinnularum ramosorum ornatis, cellulis basalibus inferiore latere nonnum-

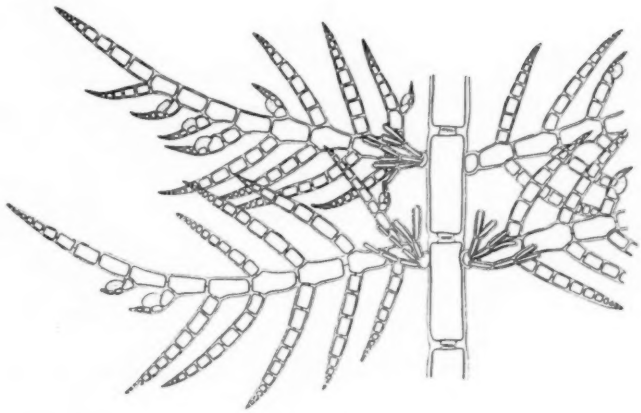

FIG. 4. *Antithamnion cristirhizophorum* Tokida and Inaba, sp. nov. Middle portion of a main branch showing pinnae, pinnulae, gland cells, and rhizoidal filaments. × 100.

quam etiam pinnula singula simplici vel ramoso ornatis; pinnis transversalibus lateralibus minoribus, irregulariter ramosis; pinnulis ultimis subulatis, cellulis apicalibus ca. 5 μ crassis; ramis principalibus usque ad 120–160 μ crassis, cellulis diametro 1–3-plo longioribus, cellulis apicalibus 14 μ altis, 10–12 μ crassis, cellulis basalibus superiore (interiore) latere plerumque nulla pinna laterali ornatis; cellulis glandulinis numerosis, supra unam cellulam lateraliter sitis, usque ad 34 μ × 30 μ; chromatophoris numerosis, taeniatis; rhizoidibus a cellulis basalibus pinnarum inferiorum emittentibus, 10–30 μ crassis; tetrasporangiis in pinnis sessilibus, 36 μ × 34 μ, cruciatim divisis; spermatangiis et ramulis carpogonatis ignotis.

Frond up to 2 cm. high, repeatedly subdichotomously branched, with whorls of four pinnae; the two lateral pinnae in mature stages very short, 80–200 μ long, 22–46 μ diam. at the base, with 5–7-celled axis, which is oblanceolate, pectinate on the upper side, with two rows of branched pinnulae in the lower portion, sometimes with also a single pinnula, simple or branched, on the lower side of the basal cell; the two transverse pinnae smaller than the lateral ones, irregularly branched; ultimate pinnulae subulate, ca. 5 μ diam. at the apex; main branches up to 120–160 μ diam., with cells 1–3 times as long as broad, apical cells 14 μ long, 10–12 μ diam., basal cells usually with no lateral pinna on the upper (inner) side; gland cells numerous, sitting laterally on one cell, up to 34 μ × 30 μ; chromatophores numerous narrow bands; rhizoids produced from the basal cells of lower pinnae, 10–30 μ diam.; tetrasporangia sessile on pinnae, 36 μ × 34 μ, cruciately divided; sexual organs unknown.

Japanese name: ONI-NO-YOTSUBAGUSA (nom. nov.).

Type: Growing on the shells of *Ostrea*, collected off the shore near the Fisheries School, Tateyama, Prov. Bōshū. *T. Inaba 403*, Apr. 18, 1944 (Herbarium, Dept. Fish., Hokkaido Univ.).

One of the leading characters of this new species is that the larger (pinnae laterales) of the two pairs of pinnae is comparatively short, usually 1–1.5 times, but rather rarely more than two times, as long as the diameter of the cells of the main axis. Since both the lateral and transverse pinnae are short and adorned with ultimate ramuli, which are sharply acute at their apices as in other

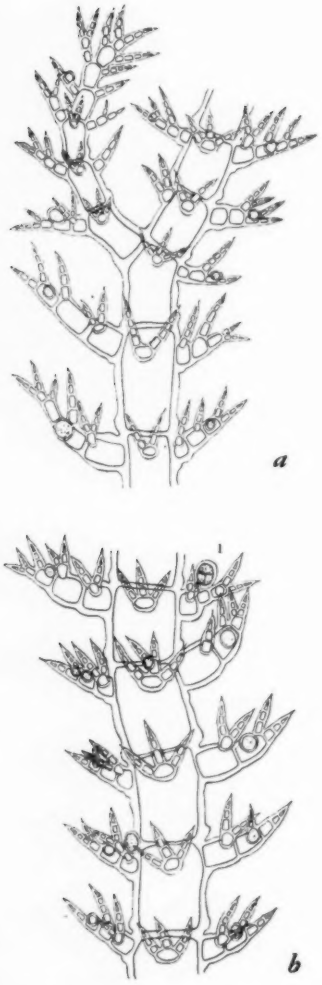

FIG. 5. *Platythamnion horridum* Tokida and Inaba, sp. nov.: *a*, middle portion of a frond, showing the mode of branching, pinnae laterales, pinnae transversales, and gland cells; *b*, the same, showing a tetrasporangium (1). *a* and *b*, × 150.

known species of the genus, the main axis looks as if it bore verticillate spines on each segment, and the frond presents as a whole a quite spiny appearance. The specific name as well as the Japanese name is given with reference to this appearance. The frond is

FIG. 6. *Platythamnion horridum* Tokida and Inaba, sp. nov. Type specimen. × 4.

subdichotomously branched, and the branches often lack an adaxial lateral pinna on their lowermost cell. In these respects our species does not differ from other known species of *Platythamnion* (cf. Kylin, 1925: Fig. 34*a*; Tokida, 1942: Fig. 8*b*).

Acrothamnion pulchellum[3] J. Agardh

Figs. 8; 9*a–e*; 10*a–f*; 11

J. Agardh, Analecta Algologica, p. 25, pl. 1, figs. 6–10, 1892; De Toni, Sylloge Algarum, 6: 451, 1924 (*nomen*). (*non Acrothamnion pulchellum* as interpreted by Yendo [Notes on Algae new to Japan, V. In: Bot. Mag. Tokyo 30 (355): 262, 1916] and by Yamada [Marine Algae of Mutsu Bay, II.

[3] In accordance with Article 61 of the International Rules of Botanical Nomenclature the specific epithet *pulchellum* is not available for transfer, since *C. pulchellum* Harvey (1855) was invalidated by *C. pulchellum* C. Agardh (1828).

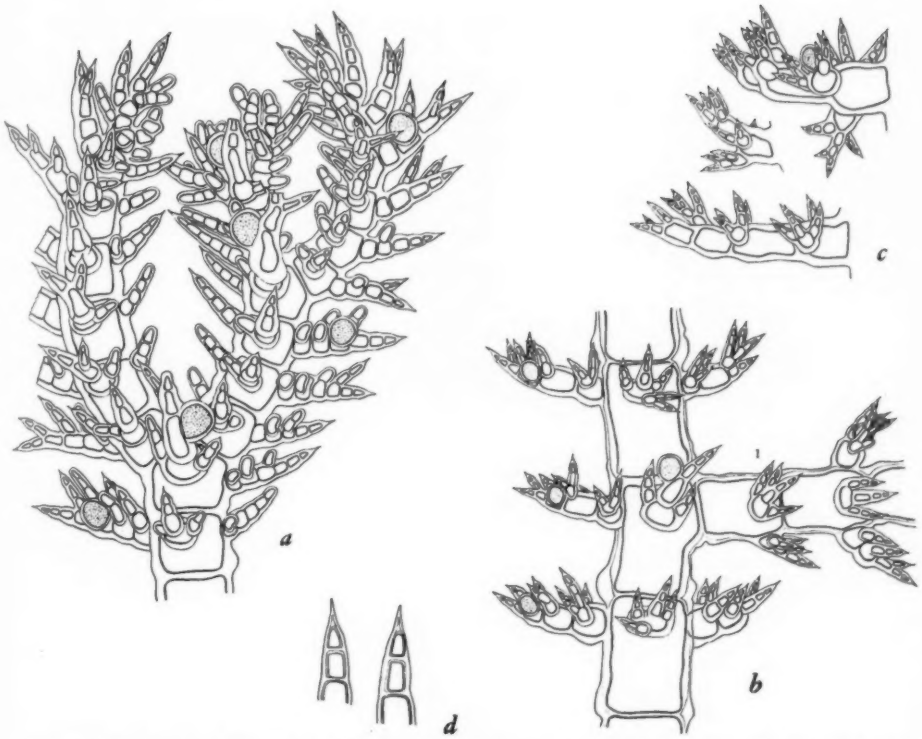

FIG. 7. *Platythamnion horridum* Tokida and Inaba, sp. nov.: *a*, apical portion of a frond, showing the growing apex; *b*, part of lower portion of a frond, showing the base of a branch, the lowest cell of which lacks the adaxial pinna (1); *c*, three pinnae laterales, showing pinnulae; *d*, tips of two ultimate ramuli. *a*, × 245; *b* and *c*, × 150; *d*, × 480.

In: Sci. Rep. Tohoku Imp. Univ., 4th Ser. Biol., 3(4): 528, Fig. 22, 1928]).

Syn. Callithamnion pulchellum Harvey. Some account of the marine botany of the colony of Western Australia. Trans. Royal Irish Academy, 22: 561, 1855; Phycologia Australis 5: Synoptic Catal., p. liv. no. 692, 1863; J. Agardh, Sp. Alg., 3(1): 20, 1876; De Toni, *loc. cit.*, 4(3): 1338, 1903; A. H. S. Lucas & Florence Perrin, The seaweeds of South Australia, II. The red seaweeds, p. 333, 1947. (*non Callithamnion pulchellum* C. Agardh, Sp. Alg., 2: 175, 1828).

Frond 5–10 mm. long, epiphytic on the thallus of *Gelidium subcostatum*, sparsely branched, partly repent, attached to the substratum by means of rhizoids arising from the basal cell of the lower, and sometimes also upper, pinnae; lateral branches arising from the basal cell of the pinnae, axial cells of the branches 37–60 μ diam. and 1.2–3 times as long as broad below, 60–86 μ diam. and 2.5–3.5 times as long as broad above, and 1–2 times as long as broad in the subapical portions, often provided with three pinnae; lateral pinnae opposite, 120–345 μ long, with opposite pinnulae on each segment except the basal; pinnulae simple or rarely once divided, attenuate but not acute toward the apices, composed of subquadrate cells slightly constricted at their septa, 10–20 μ diam. at the base, 5–10 μ diam. at the apical cells;

FIG. 8. *Acrothamnion pulchellum* J. Ag. Specimen from Shirahama. × 6.

axes of pinnae 25–30 μ diam. at the basal, 35 μ diam. at the suprabasal, and 20μ diam. at the subapical cells; transverse pinnae secund, smaller than the lateral ones, 72–280 μ long, 10–20 μ diam., simple or sparsely pinnulate above, in the latter case provided with opposite pinnulae on the apical segment and sometimes also with opposite or secund pinnulae on the subapical segments; gland cells always on the apices of pinnae and pinnulae, sitting between the two apical pinnulae on two basal cells of either of them, 10–20 μ high, 20–25 (–30) μ diam.; chromatophores discoid, numerous. Sexual reproductive organs unknown; tetrasporangia observed on a specimen from Western Australia.

Japanese name: KUJAKU-HANEMO (nom. nov.).

Specimen: Growing on the thallus of *Gelidium subcostatum* Shirahama, Prov. Bōshū *T. Inaba 351,* Mar. 11, 1944 (Herbarium, Dept. Fish., Hokkaido Univ.).

This beautiful species was discovered to be partly repent upon the thallus of *Gelidium subcostatum,* being attached by means of many rhizoidal filaments issuing from the lowermost cell of the pinnae at the lower portion of the frond and not uncommonly near the apical portion as well. The plant stands close to *Antithamnion* in the characters of the growing point and in the method of branching as well as in the possession of opposite pinnae on each segment of the main axis; but on the other hand it differs from that genus in having a single dwarf accessory pinna or transverse pinna on each axial segment of branches in addition to the above-mentioned opposite pinnae, and in having quite characteristic apical gland cells. The branches arise from the lowermost cell of either or both of the opposite principal pinnae. The axial segment of branches gives rise near the top to three pinnae in all, or two opposite larger pinnae and a single smaller pinna, of which the latter arises in the direction crossing at right angles with the plane including the two opposite pinnae. The smaller transverse pinnae are secund on one side of the main axis which corresponds to the side from which branches and rhizoidal filaments arise or to the underside of the repent portion of the frond. The principal pinnae bear two opposite pinnulae, as a rule, on each axial cell except the lowermost one. The number of the opposite pairs of the pinnulae for one principal pinna ranges from 5 to 11 (as indicated by our counts of many pinnae, amounting to 224 in all). The frequency of each number was as follows:

Number of pairs:	5	6	7	8	9	10	11
Frequency:	1	5	11	47	98	59	3

As can be seen in the listing above, the pinnae with nine pairs of pinnulae were most frequent in occurrence. The spread of two opposite pinnulae and that of two opposite pinnae measures 90–225 μ and 240–690 μ in width, respectively. The accessory pinnae or transverse pinnae, in the typical form, bear at least one pair of opposite pinnulae on the apical axial cell, which is crowned

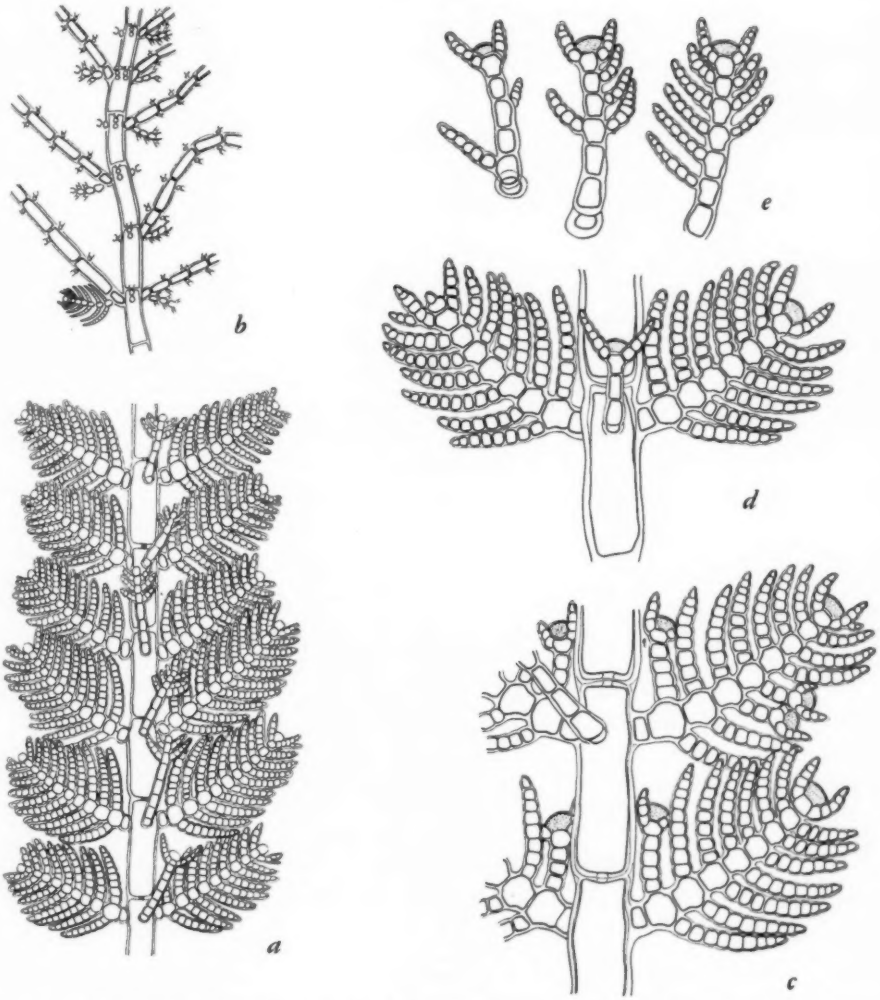

FIG. 9. *Acrothamnion pulchellum* J. Ag.: *a*, middle portion of a main branch, showing opposite pinnae laterales and secund pinnae transversales; *b*, lower portion of a frond, showing the mode of branching, details of all the pinnae but one having been omitted; *c*, six pinnulae crowned with apical gland cells; *d*, typical forms of both pinna lateralis and pinna transversalis, on the left side an exceptional pinna lacking the apical gland cell; *e*, three pinnae transversales, showing the variety of the arrangement of pinnulae. *a*, × 75; *b*, × 40; *c*, *d*, and *e*, × 150.

with a gland cell. The occurrence of pinnulae on the rest of the cells of the axes is irregular. Although the accessory pinnae are as a rule single on each axial cell of branches, sometimes they happen to be absent on certain axial cells or two may be formed from each axial cell. In the latter case, two accessory pinnae stand side by side on the same side of the frond axis. The pinnulae, either on the principal or accessory pinnae, are gen-

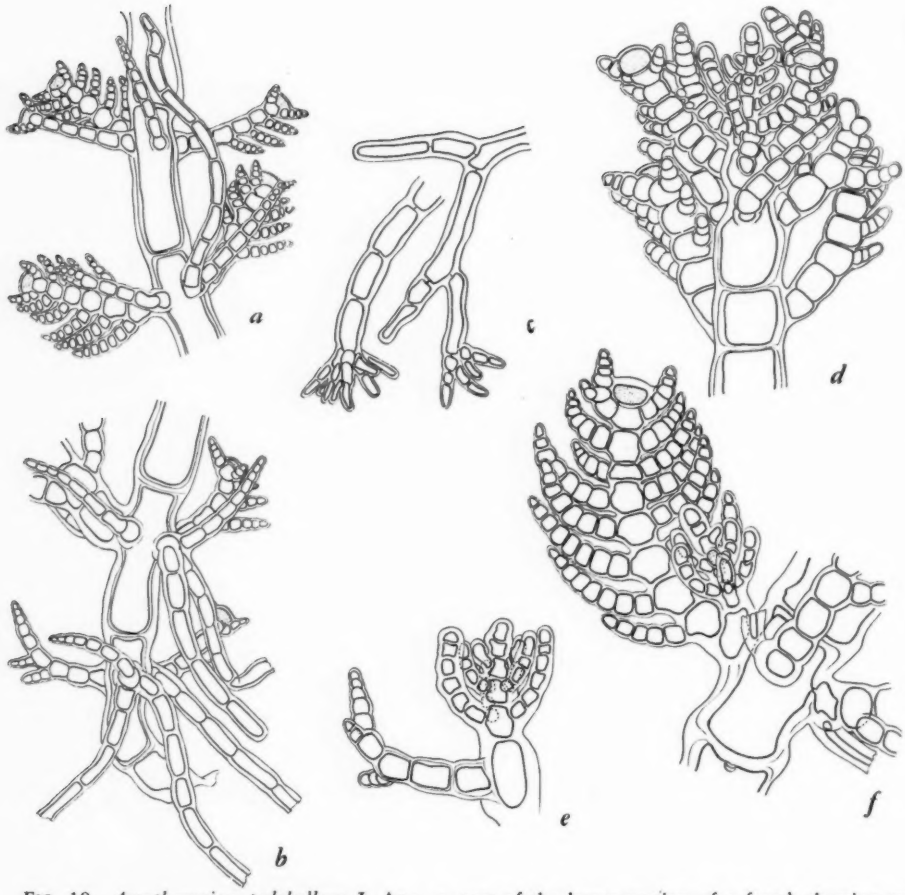

FIG. 10. *Acrothamnion pulchellum* J. Ag.: *a*, part of the lower portion of a frond, showing two pairs of pinnae transversales developing on the same side of the axis, and a rhizoidal filament arising from the lowest cell of a pinna; *b*, the same, showing rhizoidal filaments; *c*, the branching at the distal end of two rhizoidal filaments; *d*, apical portion of a short branch; *e*, very young branch developing from the lowest cell of a principal pinna; *f*, initial of a branch developing from the lowest cell of an upper principal pinna. *a* and *b*, × 150; *c*, *d*, *e*, and *f*, × 245.

erally simple, with tapering but not acute tips. Rarely some of them on a principal pinna are crowned with two opposite ramuli supporting an apical gland cell at their fork, in just the same manner as in the apex of a pinna. In the lower portion of the frond, the structure of pinnae is apt to become irregular; in other words, pinnulae often disappear partly or entirely from principal pinnae or accessory pinnae, respectively. An accessory pinna which thus remains entirely simple is no longer crowned with a gland cell. The gland cell rests solitarily at the apex of each pinna, always on five cells covering the uppermost axial cell of the pinna and two lowermost cells of each pinnula arising oppositely from the uppermost axial cell of the pinna. The principal pinnae or lateral

pinnae present a feathery appearance which reminds one of the beautiful plumes from the gorgeously eyed train of the peacock, inasmuch as they bear distichous opposite pinnulae on each axial cell (except for the basal one) and one large gland cell glittering at their apices. The Japanese name proposed for this species is based on that appearance. The reproductive organs unfortunately have not been discovered in our specimens. The description of the species given here is based upon our sterile specimens collected at Shirahama.

The writers owe the present identification to the suggestion of Prof. Y. Yamada, of the Faculty of Science in Hokkaido University, who once made a comparison of the Japanese specimens (which were then provisionally referred to *Acrothamnion pulchellum*) with Harvey's Austr. Alg., No. 539 (*Callithamnion pulchellum* Harv.), or the type specimen of *Acrothamnion pulchellum*, in Harvey's herbarium at Dublin, Agardh's herbarium at Lund, etc. (cf. Yamada and Inagaki, 1935: 37). He informed us that the authentic specimens of the species when seen under the microscope attracted his special attention by their possession of the quite characteristic apical gland cells. On the other hand, it is curious that we find no description of that organ in the diagnoses of the genus and the species given by Harvey, J. Agardh, De Toni, and Lucas & Perrin, if "*favellus*," which was described by Harvey as "favellis simplicibus rachidem plumulae terminalibus," is really comparable with the cystocarp and not with the gland cells as illustrated by J. Agardh (1892: Fig. 10) in a simple and equivocal figure. This figure seems to have nothing to do with the cystocarp but reminds us of an inflated axial cell of a pinna infected by a parasitic fungus (cf. Tokida, 1932: Fig. 5*b*). "Pinnula . . . adparenter truncata," illustrated in the same work of J. Agardh (Fig. 9), resembles quite well a simple accessory pinna lacking an apical gland cell in our Japanese plant. "Pinnulae steriles (ad *)," illustrated in Figures 6, 7, and 8, resemble abnormal lower pinnae lacking gland cells in our plant (cf. Figs. 10*b* and 10*e* in the present paper). The arrangement of the pinnae in our plant, which is distichous with two opposite compound pinnae spreading on the same plane, or, more frequently, tristichous with a more simply constructed pinna in addition to the opposite ones just mentioned, seems to agree with the description of the pinnae of *Callithamnion pulchellum* given by J. Agardh (1876), which runs as follows: "pinnis geminis conformibus distichis opposite pinnulatis, aut ternis una dispari simpliciore." As to the validity of the tetrasporangium-bearing simple and subfiliform accessory pinnula, which was described and illustrated by J. Agardh (1892: Figs. 6, 7, and 8), as a character of generic importance, we are inclined to harbour a strong doubt since we could observe sessile tetrasporangia on a fragment of Harvey's original specimen of *Callithamnion pulchellum* (Alg. Austr. Exsicc., No. 539D) through the most generous kindness of Mme. Valerie May of the Division of Fisheries, Marine Biological Laboratory, Cronulla, New South Wales, Australia. In April, 1948, the senior author received a letter from her answering his request to compare some figures of the Japanese plant drawn by himself with the authentic specimens of *Acrothamnion pulchellum* J. Ag. Mme. May kindly enclosed in her letter a fragment of Harvey's specimen deposited in the National Herbarium of New South Wales, Sydney. In examining the fragment under the microscope, it was quite satisfactorily ascertained that our Japanese plant coincides with Harvey's species in every morphological characteristic. As the fragment fortunately bears tetrasporangia, the authors wish to give here a thorough description and illustrations of them.

The tetrasporangia-bearing branch is marked by having frequently a couple of

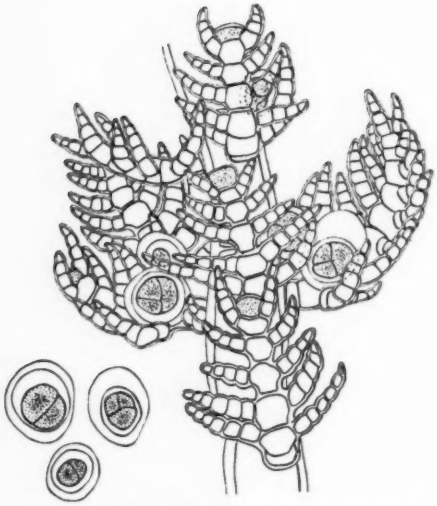

FIG. 11. *Acrothamnion pulchellum* J. Ag. Part of a tetrasporiferous fragment of Harvey's specimen (Alg. Austr. Exsicc. No. 539D) collected at Port Fairy, Victoria, in 1855, showing the sessile tetrasporangia with inflated membranes, developing on the upper side of the lower portion of the pinnae. Three sporangia in various stages of development are shown separately. × 245.

compound accessory pinnae on the ventral side of each of its segments. The sporangia mounted in glycerine-water measure 32–48 μ long and 24–44 μ wide, excluding membranes. Including the outer layer of the membrane, which is usually swollen to a remarkable extent, a sporangium is 86 μ long and 72 μ wide and contains a spore mass measuring 38 μ long and 36 μ wide. The same sporangium is 52 μ long and 48 μ wide, including the inner layer of the membrane. A young immature sporangium in which the contents are undivided and measure 20 μ by 18 μ is 38 μ long and 34 μ wide, including the inner layer of the membrane, and 60 μ long and 52 μ wide if the outer layer is included. The sporangia are sessile, standing on the adaxial (upper) side of the basal segment of, usually, the lowermost pinnule of the principal and accessory pinnae. They divide cruciately by two successive divisions, first by a transverse wall and second by two walls perpendicular to the first as well as to each other. The opposite principal pinnae are slightly bent upward and toward the dorsal side of the axis, so as to form, along with the accessory pinnae, a fence around the axis in order to protect the tetrasporangia (cf. Fig. 11).

Pleonosporium Tobyamanum

Tokida and Inaba, sp. nov.
Figs. 12*a, b*; 13*a, b*; 14*a, b*; 15*a–c*

Fronde 1–1.5 cm. alta, rhizoidibus longis et simplicibus vel ramosis, a cellulis basalibus pinnarum inferiorum deorsum vel a cellulis inferioribus axium principalium lateraliter emittentibus adfixa; axibus principalibus inferne usque ad 300–315 μ crassis, ad basin in axes nonnulus divisis, ecorticatis, cellulis diametro 1.5–3-plo longioribus, ad septa leve inflatis; ramis et pinnis alternis et distichis; cellula basali rami quadrata, pinna nulla, cellula insequenti superiore latere pinna una praedita; pinnis simplicibus vel ramosis, lineari-lanceolatis, leviter incurvis, apica obtusis, cellulis apicalibus 22–24 μ crassis, cellulis basalibus pinnarum inferiorum in ramis inferioribus inferiore latere pinnulis simplicibus vel ramosis; chromatophoris numerosis, brevibus et taeniatis; sporangiis in pinnis et pinnulis sessilibus, plerumque in latere superiore secundis, sed raro etiam in latere inferiore sparsis, ellipsoideis, 70–106 μ longis et 50–78 μ latis, sporis pluribus ornatis; antheridiis in latere superiore ramulorum ultimorum secundatis; procarpiis subterminalibus; cystocarpiis terminalibus, ramulis involucrantibus nullis; cellula glandulina nulla.

Frond 1–1.5 cm. high, attached to the substratum by means of simple or branched rhizoidal filaments, being produced downwardly from the basal cell of the lower branches or laterally from the lower segments of the main axes; main axes up to 300–315 μ diam. below, divided into several main axes near the base, uncorticated, with cells 1.5–3 times

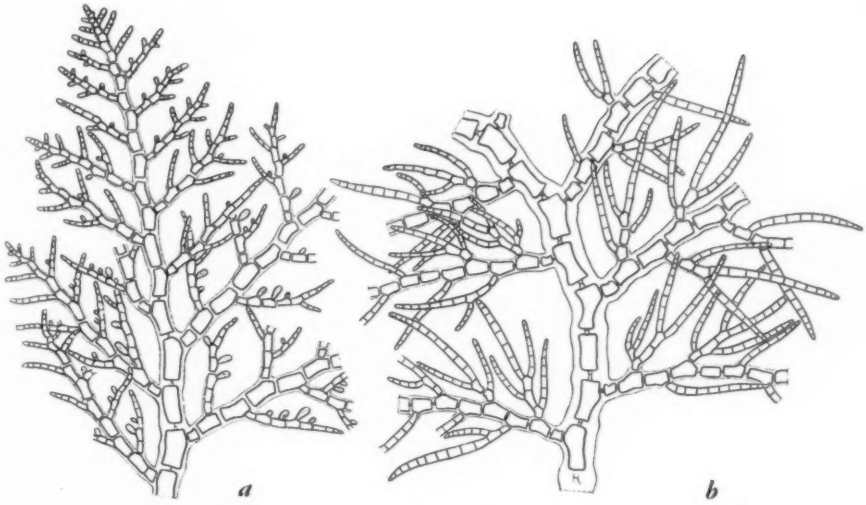

FIG. 12. *Pleonosporium Tobyamanum* Tokida and Inaba, sp. nov.: *a*, apical portion of a main axis; *b*, lower portion of a main axis, showing branching of the side branchlets on the lower segments of the branches. *a* and *b*, × 33.

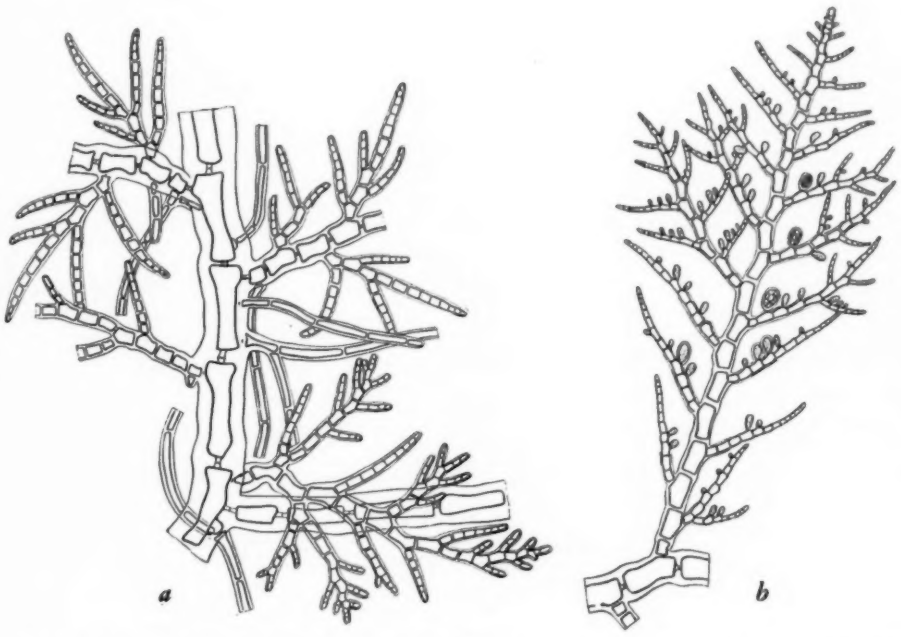

FIG. 13. *Pleonosporium Tobyamanum* Tokida and Inaba, sp. nov.: *a*, branch with sporangia; *b*, basal portion of a frond, showing rhizoids. *a*, × 40; *b*, × 65.

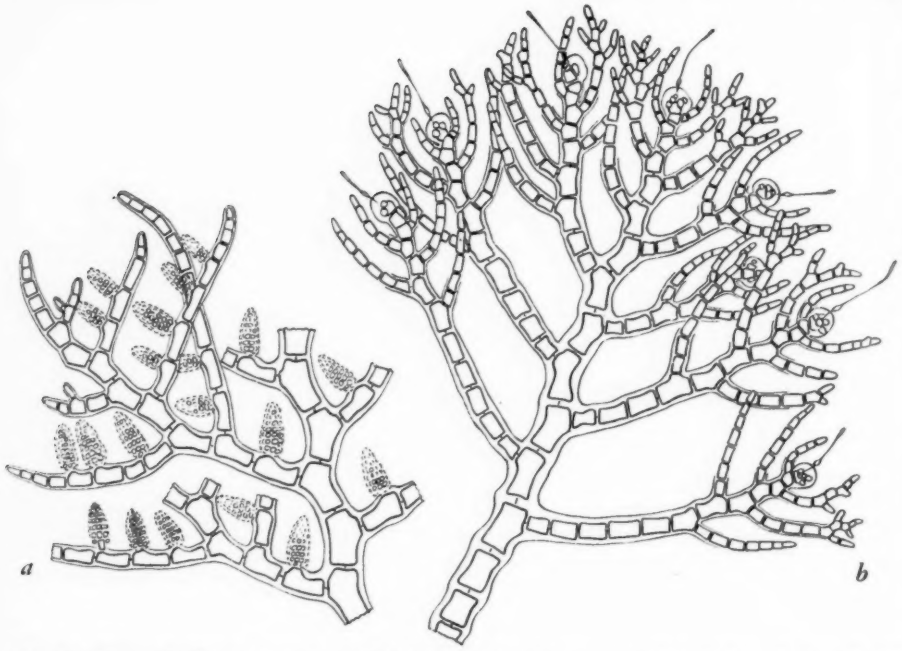

FIG. 14. *Pleonosporium Tohyamanum* Tokida and Inaba, sp. nov.: *a*, apical portion of a branch with procarps; *b*, branch with antheridia. *a*, × 150; *b*, × 98.

as long as broad, slightly inflated at joints; branches and pinnae alternate and distichous; the lowermost cell of branches quadrate, with no pinna, the next cell with a pinna on the adaxial side; pinnae simple or divided, linear-lanceolate, slightly incurved, blunt at the apex, 22–24 μ diam. at the apical cells, with a simple or divided pinnula on the abaxial side of the lowermost cell of a few lower pinnae in the lower branches; chromatophores numerous, short slender bands; sporangia sessile, usually secund on the adaxial side of pinnae and pinnulae but rarely also scattered on the abaxial side of pinnae, ellipsoidal, 70–106 μ long and 50–78 μ broad, with many spores; antheridia secundate on the upper side of the ultimate ramuli; procarps subterminal; cystocarps terminal, with no involucre; gland cell absent.

Japanese name: TOHYAMA-KUSUDAMA (nom. nov.).

Type: Growing on rocks, Mera, Prov. Bōshū. *T. Inaba 402*, Apr. 10, 1944 (Herbarium, Dept. Fish., Hokkaido Univ.).

In 1917, Yendo (1917: 91) referred a plant of *Pleonosporium* from Cape Inubō to *P. venustissimum* (Kütz.) De Toni, no doubt following the specific conception entertained by De Toni (1903), who had amalgamated *P. vancouverianum* J. Ag. with this species. Kylin (1925: 57) has disagreed with De Toni's view, stating that: "Kützing's figure (Tab. Phyc., 12: pl. 1) shows that in *C. venustissimum*[4] the side branch from the undermost cell of a branch often occurs on the upper side, but in *Pl. vancouverianum* it always occurs on the lower side." If that be the case, there arises a question as to the nature of the side branch under consideration in Yendo's plant.

[4] As a species of *Callithamnion*.

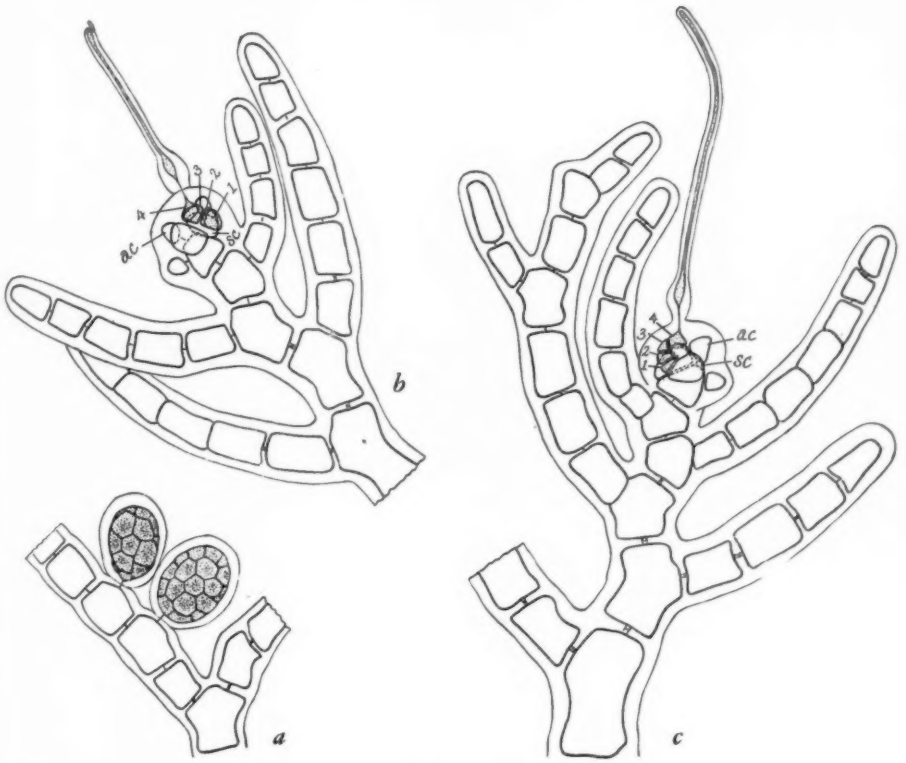

FIG. 15. *Pleonosporium Tohyamanum* Tokida and Inaba, sp. nov.: *a*, two sporangia; *b* and *c*, apical portions of fertile pinnae, showing carpogonial branches: 1, 2, 3, and 4, carpogonial branch cells; sc, supporting cell or fertile pericentral cell, provided with a carpogonial branch and a sterile cell; ac, apical cell of the pinna. *a*, × 150; *b* and *c*, × 344.

In the spring of 1944, the junior author collected a *Pleonosporium* at Mera, Bōshū province, not far distant from Cape Inubō. In general characters it resembles the two species mentioned above, but is not identical with either of them, differing in certain respects, especially in the entire absence of the side branch or pinna on the lowermost cell of a branch. The side branch on the cell next to the lowermost one arises always on the adaxial side of the branch. In this respect our plant shows a resemblance to *P. vancouverianum* rather than to *P. venustissimum*. According to the brief description by Yendo, the main branches of his plant seem to have somewhat longer cells than those of ours. As to the rhizoidal filaments. Yendo describes merely those growing downward from the basal cell of the pinnae, while our plant has in addition lateral rhizoidal filaments which issue from the lower segments of the main axis and which rarely become as thick as the main axis (Fig. 13*b*). It is quite probable that our plant is identical with Yendo's, but at present we cannot settle the question as we have had no chance to examine Yendo's original specimen. In any event, we believe the plant in question is new to science, and

we propose here to name it *Pleonosporium Tohyamanum* in honour of Mr. Nobuo Tohyama, director of the Fishery Experiment Station of Chiba prefecture, through whose kindness the authors have obtained many facilities for carrying out their phycological studies.

SUMMARY

1. In this paper is reported the discovery of four species of red seaweeds which are considered to be new to science and which belong to the genus *Antithamnion* and its allied genera in the family Ceramiaceae. The occurrence of an Australian species of the same group from the coast of Bōsō Peninsula near Tokyo Bay is also reported.

2. New species here described are as follows: *Antithamnion basisporum, Antithamnion cristirhizophorum, Platythamnion horridum,* and *Pleonosporium Tohyamanum.*

3. The occurrence in the northwestern part of the Pacific Ocean of *Acrothamnion pulchellum* J. Ag., which was originally reported from the west and south coasts of Australia in 1855, is established by comparing Japanese specimens with a fragment of Harvey's original specimen collected at Port Fairy, Victoria.

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Harpodon nehereus, a Non-luminous Fish

YATA HANEDA[1]

THE GENUS *Harpodon* of the fish family Synodontidae is found in the seas of India, Burma, Malaya, Sumatra, Java, Borneo, Thailand, Indo-China, and China. It has been recorded from Zanzibar and East Africa; a single species has been recorded from Japan.

Four species appear to be known: *Harpodon nehereus, H. squamosus, H. macrochir,* and *H. mortenseni.*

The first, *H. nehereus* (Ham. Buch.), is the commonest and occurs in varying abundance in shallow coastal waters and estuaries, mostly in India, Burma, Malaya, Java, Sumatra, and Borneo. When salted and dried it forms the well-known product known as Bombay duck, or bummaloe, which serves as a condiment with curries. In Malaya, Java, and Sumatra it is generally known either alive or dead as ikan lumi or luli or aruan tassik, although occasionally it may have other names in scattered localities. As far as is known, *H. nehereus* is the only species found in Malaya (Günther, 1864; Fowler, 1938).

The first scientific reference to the fish known as "Bombay Duck" is found in Hamilton's book on Gangetic fishes (Hamilton-Buchanan, 1822). The species was discovered by him in the mouths of the Ganges, and was doubtfully referred to the genus *Osmerus.* However, in 1825 Lesueur proposed the genus *Harpodon* for Hamilton's species of *Osmerus.* The synonyms of *H. nehereus* are numerous. It was first known as *Osmerus ? nehereus* (Hamilton, 1822) then later as *Salmo (Harpodon) microps* (Lesueur, 1825), *Saurus Ophiodon* (Cuvier et Valenciennes, 1849), *Saurus nehereus* (Cantor, 1850), and finally as *Harpodon nehereus.*

The second species, *H. squamosus,* was taken in deep water in the Bay of Bengal, at depths varying from 120 to 300 fm., and was described by Alcock in 1891.

The third species, *H. macrochir,* was named by Günther (1887: 180) from a single specimen from Tokyo, Japan. Neither the depth nor the locality in which it was caught is known.

The fourth species, *H. mortenseni* (Hardenberg, 1933), was caught by trawl at a depth of 300 m. by Dr. Mortensen, after whom the species was named. It was taken in the Bali Sea.

There seems to be no reason why *H. squamosus* should not be admitted to the deep-sea fauna on the evidence available; however, there is no evidence to show that either *H. macrochir* or *H. nehereus* is a deep-sea fish.

Günther (1887) says the species *H. macrochir* is named from a single specimen 27 inches long which was obtained at Tokyo, Japan, although at what depth it was taken is not known, "but it is evident from its organization that it should be referred to the deep sea fauna."

Boulenger (1904) states that *Harpodon nehereus* is adapted to a bathybial existence, and at the same time comments on its luminosity, although stating that it is not known to inhabit deep water and is not confined to the sea but is abundant in estuaries. He points out further that *H. squamosus* lives in depths from 120 to 300 fm. but says nothing about its luminosity. Since so many statements have appeared in ichthyological publications concerning its luminosity, I decided

[1]Tokyo Jikeikai Medical College. Manuscript received January 28, 1949.

to ascertain the nature of the luminosity, and, if it was found to be luminous, to locate and describe the luminous organs.

Cuvier and Valenciennes (1849), discussing the economic uses of this fish, stated that they were informed "that when exposed to the air they give out during the night a living phosphorescent luminescence." Cantor (1850) said, "It is very short lived . . . and the whole body becomes at certain seasons brilliantly phosphorescent." Günther (1880: 584) stated "that when newly taken its body is brilliantly phosphorescent." Kemp (1917: 238), in his observations on specimens from the Matlah River, was not able to corroborate this statement. Hora (1934) also agrees with Kemp's observations. Boulenger (1922: 613) states that "*H. nehereus* when newly taken is brilliantly phosphorescent all over the body." Kyle (1926) wrote of "the remarkable *Harpodon* which when caught becomes brilliantly luminescent all over the body." Norman (1931) stated "it is brilliantly phosphorescent all over when newly caught without possessing any light producing organs."

Whether these statements are the results of personal observation is not known, but they seem to refer to the condition of the fish after it has been caught or "newly caught," whatever this may mean.

Cuvier's material was undoubtedly dead, as was Cantor's, since the latter comments on the fact that the fish is short lived. None of the other statements refers to actual living material, and the expression "newly caught," at least as far as Malayan material is concerned, may have no significance whatever for the following reasons.

The *Harpodon* which are caught in Malaya are taken in nets which are set in estuaries, or between adjacent islands where there is a strong tidal stream during the ebb and flood of the tides.

The nets are long bag-like affairs with meshes almost as fine as those of coarsely woven sackcloth. They lie on the bottom and are furnished with a wide-open mouth which faces the current. Through this mouth is swept into the nets, by the tidal stream, a mixed assortment of feebly swimming fishes, squid, crustacea, jellyfish, and a miscellaneous assortment of debris from the land, such as leaves, twigs, etc. Once in the net there is no escape for those animals which cannot swim against the stream, and they remain crammed and compressed in the net by the constant addition of material which collects there.

The nets remain there without attention until slack water, when they are lifted, emptied, and reset to face the stream as it reverses its direction with the change of tide. Most of the fishes and other animals are dead or dying when the nets are lifted, and only those caught last may be alive, since they are not subjected to anything but the pressure of the water.

The time during which the nets remain unattended is about 6 hours, and most of the catch is taken during that 3-hour period when the tidal stream flows strongest, which may occur an hour to an hour and a half after the setting of the net and last until an hour to an hour and a half before lifting it. There is a further delay in the handling of the catch when the fishermen have to lift the nets, dump the catch into a boat (incidentally dumping the dead on top of the more recently caught, crushing and killing them in turn), and then row their catch ashore for sorting. This may account for a delay of at least an hour if not more, and it should be realised that by this time there is little chance of securing any living specimens of such a feeble, short-lived fish as *Harpodon*. "Newly caught" material may have been dead for 5 to 6 hours at the most and for 2 or 3 hours at the least, and this fact is very important. There is no definite record of any observation on the luminosity of actually living material. In order to secure live specimens I had to

stay by the nets, hoping that with careful sorting there might be some living material available when the nets were lifted.

Fortunately I was able to secure some, and the results will show the significance of distinguishing between living material and that which may have been the material described so often as "newly caught."

I examined very carefully a considerable amount of dead but fresh material in the Singapore Fish Market during November, 1943, and February, 1944, in order to determine whether there were any luminous organs or luminous spots, but failed to find any. In April, 1944, I was able to obtain living material by crossing over to Karimon and actually staying by the nets which are set in the Gelam Straits off Tanjong Balai, Karimon Island, Rhio Archipelago.

It is significant that of all the living specimens I obtained, not a single one displayed the slightest luminescence. On the other hand, all of the dead specimens were strongly luminescent. In some cases the whole body was luminous; in others only a part was luminous. Moreover, the luminosity in some cases was confined to the surface of the whole body, while in others it could be seen deep inside the body.

Another interesting observation was that the luminosity of *Harpodon* was much brighter than that of the other kinds of fish, crustaceans, etc., in the catch, which, incidentally, were luminous, but to a lesser degree.

Bacteriological cultures were made from both the outside and inside of the bodies of this dead luminous material, and subjected to the usual bacteriological tests. The results indicate that the luminosity of *Harpodon,* when dead, is due simply to luminous saprophytic bacteria and that it differs in no way from that which can be observed in other dead fish and other animals taken at the same time.

It must not be overlooked that the flesh of *Harpodon* is almost like jelly, possessing an extremely high water content, and is an excellent medium for the easy invasion and rapid development of bacteria, much more so than the tough muscular flesh of other fishes and crustacea.

The rapidity with which bacteria develop in tropical countries is well known, and this case furnishes an excellent illustration. In 4 to 5 hours after death the effects of luminous bacteria are already visible on the surface of the body. After 7 to 8 hours luminosity can be seen to have extended to the innermost parts of the body.

It is clear, therefore, that what is meant by "newly caught" material should be expressed more precisely. More frequently this expression means "newly landed" either at the place normally used by fishermen for landing their catches, or perhaps in the market place, miles from where the fish were caught. The primitive and slow methods of handling and marketing fish in tropical countries are proverbial and there would be ample time for *Harpodon* to become luminous as a result of bacterial action even if "newly caught" according to tropical standards.

Luminosity is so associated with deep-sea fishes that it seems to be considered a reasonable possibility that if a fish is either luminous or an inhabitant of the deep sea it is probably both, especially if it has any resemblance to some well-known form of luminous deep-sea fish.

With its gaping mouth, large teeth, small eyes, and soft body, the resemblance of *Harpodon* to some of the Chauliodontidae might well encourage the belief that it was a deep-sea fish, and that the luminosity seen after death was normal during life. This resemblance to a deep-sea form misled even so great an authority as Günther (1880: 584).

Acknowledgment: I wish to express my hearty thanks to Mr. W. Birtwistle, former Director of the Fisheries Department of Singapore and Federated Malay States, who helped me in many ways during my stay in

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The Noctuidae Catocalinae from New Caledonia and the New Hebrides (Lepidoptera)

PIERRE E. L. VIETTE[1]

THE LEPIDOPTEROUS FAUNA of New Caledonia and the New Hebrides has not been studied extensively. I have dealt elsewhere with the whole of the Rhopalocera (Viette, in press) and have prepared a catalogue of the known Heterocera from these regions (Viette, 1949).

In this paper are presented means of determining the known species of Noctuidae Catocalinae and descriptions of male and female genitalia which complete the original descriptions of these species. Material in the Department of Entomology of the National Museum of Paris has made this work possible.

The subfamily Catocalinae is well represented in New Caledonia and the New Hebrides as it is in all warm regions but, as an effect of the relative poorness of the fauna of these regions, there are not very many species. Most of these species are known from southern Asia and the other Pacific archipelagoes.

This subfamily is distinguished by having M_2 well developed in the posterior wings (Noctuidae Quadrifidae), M_1 and M_2 more or less convergent toward their base, the middle tibiae with little spines, and the male retinaculum not having the shape of a small tongue. The venation is the same for the whole subfamily, for which reason it is described here: R_1 is free; an areola is present; R_2 arises from the apex of the areola as do R_3 and the common stalk to R_3 and R_4; M_1 arises from the superior angle of the medial cell or a little below; M_3 and Cu_{1a} are separated from the inferior angle. In the posterior wings, the medial cell extends through a third or a half of the wing; R and M_1 arise from the same point, the superior angle of the medial cell; M_2, M_3, and Cu_{1a} are plainly separated from the inferior angle.

[1]Department of Entomology, National Museum of Natural History, Paris. Manuscript received April 1, 1949.

Key to the Genera

1. Metathoracic tibiae without spines . . . . . **Parallelia**
   Metathoracic tibiae with spines 2
2. Prothoracic tibiae without spines 3
   Prothoracic tibiae with spines 8
3. Metathoracic tibiae with spines only between the medial and the terminal spurs . . . . . **Lagoptera**
   Metathoracic tibiae with spines only above the medial spurs 4
4. Abdomen with hairs dorsally 5
   Abdomen with scales dorsally 6
5. Frons with a tuft of hairs dorsally . . **Anua**
   Frons without a tuft of hairs dorsally . . . . . **Achaea**
6. Posterior wings with a normal medial cell, extending to about the middle of the wing . . . . . **Mocis**
   Posterior wings with a small medial cell, not extending one-third of the length of the wing 7
7. Antennae reaching the third quarter of the costa . . . . . **Chalciope**
   Antennae reaching the middle of the costa . . . . . **Grammodes**
8. Labial palpi with the second joint widened, spatulate . . . . . **Phyllodes**
   Labial palpi with the second joint normally formed . . . . . **Cocytodes**

Genus COCYTODES Guénée

Cocytodes Guénée, 1852, Spec. Gén. Lépid., Noct. 3: 41; Hampson, 1894, Fauna Brit. India, Moths 2: 485; 1913, Cat. Lepid. Phal. B.M. 12: 258; Gaede, 1938, in Seitz 11: 457 (type *coerulea* Gn.).

The proboscis is fully developed; the labial palpi are upturned, the second joint reaching the middle of the frons. The frons is smooth, clothed with flattened hairs and scales. The male antennae are simple. The thorax is clothed with hairs, without a crest. The tibiae are fringed with long hairs and have spines. The medial cell of the posterior wings extends about one-third of the wing.

One species only is known from these regions.

Cocytodes coerulea Guénée

Fig. 1*a–c*

Cocytodes coerulea Guénée, Spec. Gén. Lépid., Noct. 3: 41, pl. 13, fig. 10, 1852.
Arcte caerulea Guénée; Hampson, Fauna Brit. India, Moths 2: 486, fig. 272, 1894.
Cocytodes caerulea Guénée; Hampson, Cat. Lepid. Phal. B. M. 12: 259, fig. 33, 1913.
Cocytodes coerulea Guénée; Tams, Ins. of Samoa, Lepid. 4: 214, 1935.
Cocytodes caerulea Guénée; Gaede, in Seitz 11: 457, 1938.
Cocytodes caerulea Guénée; Viette, Pacific Science 3(4): 330, 1949.

Wingspread 86–88 mm.; length of the anterior wings 37–38 mm.

The head and the thorax are reddish brown, the abdomen is gray. In the male, there is a strongly sclerotized subrectangular plate in the middle of the tergite of the sixth segment which is transversely striped with black (Fig. 1*b*).

The anterior wings and thorax are reddish brown irrorated with bluish white scales, especially in the proximal part of the wing; the subbasal line is black, slightly oblique and sinuous; the orbicular spot is black and small;

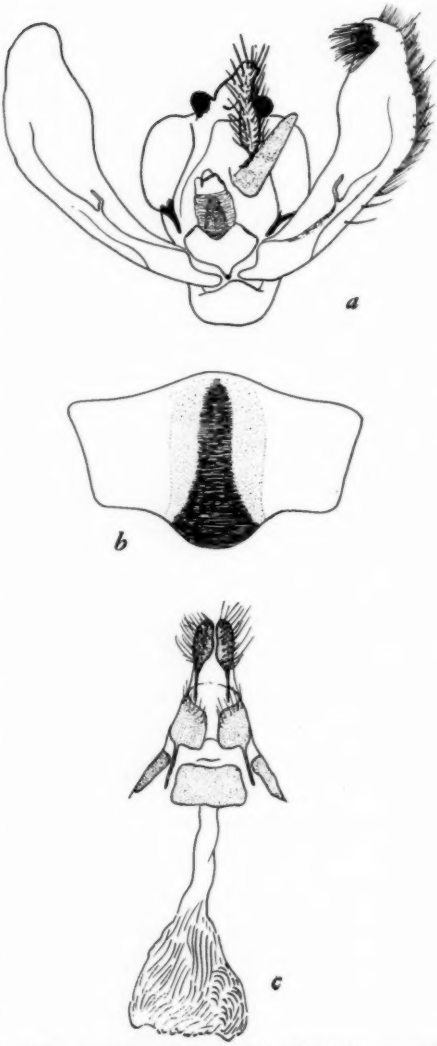

FIG. 1. *Cocytodes coerulea* Guénée: *a*, male genitalia; *b*, tergite of the eighth abdominal segment; *c*, female genitalia.

the reniform spot is well marked; the postmedial line is at first oblique with regard to the costa, then, on a level with M_3, becomes almost parallel to the latter, and finally reaches almost perpendicularly the inferior edge of the wing at its distal third; a large

part of the wing is dark, only the apex and the costal area are really reddish brown.

The posterior wings are blackish brown with purple tracings, which include a medial spot, a spot in the middle of the abdominal edge, a submarginal band, and a very narrow marginal band between Cu_{1b} and A_2.

The underside is lighter than the upper side. The anterior wings have an indication of a dark, transverse band edged with gray. The posterior wings have the tracings of the upperside well marked. The underside of the body is a dirty white.

Genitalia ♂: (Fig. 1*a*). The tergite of the sixth urite has a middle plate which is striped transversely (Fig. 1*b*). The tegumen is not much developed dorsally but carries laterally large processes which are suddenly thinned at their apex and end in a well-sclerotized and strongly colored point; the uncus is directed downward, it is hairy and sharp at its extremity; a scaphium is present; the vinculum is not much developed; the valvae are long, widened at the end; a small angular process is present about the middle of the dorsal edge of the sacculus; the juxta has almost the shape of a V; the penis is asymmetrical without cornuti.

Genitalia ♀: (Fig. 1*c*). Simple, the lobes of the oviporus are normal, with posterior apophyses; the eighth urite is unsclerotized in the medioventral area; the anterior apophyses are present; the ostium bursae is membranous as is the bursa copulatrix and the ductus bursae; the bursa copulatrix is ornamented with unsclerotized folds.

New Caledonia (Layard): Pouerihouen (Quod), Canala (Delacour), Baraoua (Catala).

Loyalty Islands: Lifu (Whitmei).

New Hebrides (Mathew).

The species extends from India to Fiji and Samoa.

Genus PHYLLODES Boisduval

Phyllodes Boisduval, 1832, in Dumont d'Urville, Voyage de l'Astrolabe, Lepid. 1: 246; Hampson, 1913, Cat. Lepid. Phal. B.M. 12: 389; Gaede, 1938, in Seitz 11: 470 (type *conspicillator* Cr.).

The proboscis is fully developed; the labial palpi are upturned; the second joint strongly widened, spatulate; the third joint small, normal, and dilated at its apex; the frons is smooth with a thick tuft of hairs; the antennae are filiform, reaching the middle of the costa. The thorax is clothed with hairs, without crest; the anterior wings have a strongly arched costa and the apex is slightly projected; in the posterior wings the medial cell does not extend as much as one third of the wing.

Only one species is of interest here.

Phyllodes imperialis Druce

Fig. 2*a, b*

Phyllodes imperialis Druce, Ann. and Mag. Nat. Hist. VI, 2: 241, 1888.

Phyllodes imperialis Druce; Hampson, Cat. Lepid. Phal. B.M. 12: 392, pl. CCXI, fig. 5, 1913.

Phyllodes meyricki imperialis Druce; Gaede, in Seitz 11: 470, pl. 48 b, 1938.

Phyllodes imperialis Druce; Viette, Pacific Science 3(4): 330, 1949.

Wingspread 159–175 mm.; length of the anterior wings 78–80 mm.

This is one of the most beautiful and largest of the moths from New Caledonia and the New Hebrides. The head, the thorax, and the abdomen are abundantly clothed with reddish gray hairs, with a light purple tint on the head, the patagiae, the inferior edge of the tegulae, and the abdomen.

The anterior wings are very wide, with the external margin and the inferior edge describing an arc of a circle; the costa is strongly arched in its apical part and the apex is slightly projected. The background color is rusty brown, more or less dark according to the specimens, with the variable tracings

more or less marked; the most variable tracing is the spot, without a distinct margin, which is found at the apex of the cell and the color of which varies from greenish white to a lighter shade of the background color. When they are well marked three transverse basal bands which are a little darker than the background color can be distinguished. There are also a slightly arched line which passes through the middle of the spot, and a line that starts at the apex runs almost parallel to the costa as far as Cu_{1b} and is there directed toward the inferior edge of the wing.

The space outside this line is lighter in color.

The posterior wings are black with a gray base. A lengthened spot, more or less bright pink, and a marginal band of white spots, typically triangular extend from the anal angle to the middle of the wing; each spot is found between veins.

The underside of the anterior wings is grayish, and the medial space is black with three whitish spots; the posterior wings are gray; the abdominal space is black with the pink spot; the body and the legs are gray.

Genitalia ♂ : The tegumen is not strongly developed and has a narrow and thin uncus, first turned upward, then downward; the apex is sharp, the dorsal part of the uncus is clothed with bristles; the vinculum is rather broad, lengthened toward the frons but does not form a real saccus; the anal tube has a well-developed scaphium; the valvae (Fig. 2*a*) are subrectangular with a short expansion in the area of the external ventral angle; in the middle of the internal surface is a narrow process; the juxta is well developed and the penis is short, in part membranous in its apical region.

Genitalia ♀ : The lobes of the oviporus are almost square; the posterior apophyses are normal; the eighth urite is entirely sclerotized, showing a differentiated plate in the middle ventral area above the ostium bursae; this, although not specialized, is clearly indicated; the ductus bursae is highly sclerotized in the part connected with the ostium bursae; the bursa copulatrix is large, with small sclerotized marks (Fig. 2*b*).

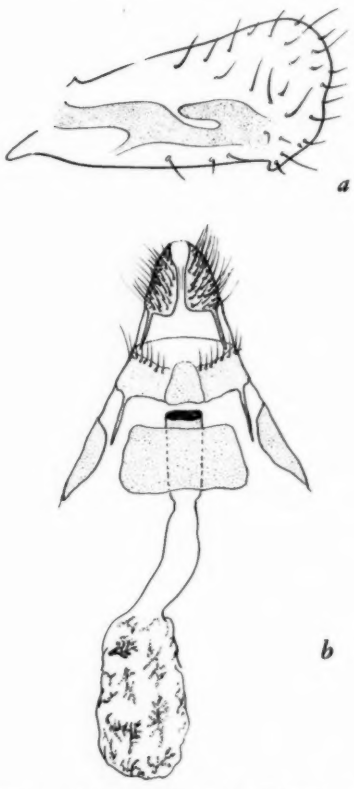

FIG. 2. *Phyllodes imperialis* Druce: *a*, right valva of male; *b*, genitalia of female.

New Caledonia (Millot).

Loyalty Islands (coll. de Joannis).

New Hebrides (Hampson l.c., Mrs. Pruvot, coll. de Joannis).

Genus LAGOPTERA Guénée

Lagoptera Guénée, 1852, Spec. Gén. Lépid., Noct. 3: 223; Hampson, 1913, Cat. Lepid. Phal. B.M. 12: 413; Gaede, 1938, in Seitz 11: 471 (type *honesta* Hb.).

The proboscis is fully developed; the labial

palpi are upturned, with the second joint lengthened to reach the vertex of the head; the third joint is short; the frons is smooth; the male antennae are ciliated. The thorax is clothed with hairs, without crest; the pro- and metathoracic tibiae of the males are fringed with long hairs; the prothoracic tibiae have no spines and the metathoracic tibiae have spines only between the medial and apical spurs. In the male, the underside of the posterior wings is entirely clothed with specialized scales (the androconiae of Hampson, 1913). The first segments of the abdomen carry tufts of hairs dorsally.

Only one species is known from this area.

Lagoptera miniacea Felder

Fig. 3*a–c*

Lagoptera miniacea Felder, Reise Novara, Lepid., pl. 116, fig. 8, 1874.

Lagoptera miniacea Felder; Hampson, Cat. Lepid. Phal. B.M. 12: 416, 1913.

Lagoptera miniacea Felder; Tams, Ins. of Samoa, Lepid. 4: 214, 1935.

Lagoptera miniacea Felder; Gaede, in Seitz 11: 471, pl. 49 b, 1938.

Lagoptera miniacea Felder; Viette, Pacific Science 3(4): 330, 1949.

Wingspread 88–92 mm.; length of the anterior wings 43–45 mm.

The head and the thorax are reddish brown, more or less dark, the vertex with a little white line; the abdomen is light reddish brown anteriorly, the rest is pale red.

The background color of the anterior wings is that of the thorax irrorated with black and bluish white scales. At the extremity of the medial cell is found a black spot (the reniform spot), which is usually rather large, but which can become greenish white, or can be reduced to a little black point, or can even be absent; a basal dark line, lightly waved, exteriorly bent, is seen; the postmedial line is straight, dark; an indication of some black spots between M_1 and M_2 is sometimes seen in the marginal area.

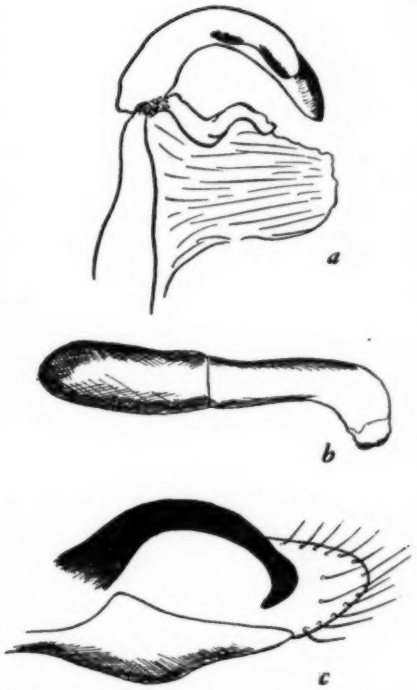

FIG. 3. *Lagoptera miniacea* Felder: *a*, tegumen, uncus, and anal tube; *b*, penis; *c*, right valva.

The posterior wings are pale red with an indication of a black spot at the apex of the medial cell and a marginal black band with pale red on the external margin.

The underside of the wings is pale red; the legs are of this color with the underside black, irrorated with bluish white scales.

Genitalia ♂: The tegumen is not much developed, being almost indistinct; the uncus is strongly developed (Fig. 3*a*), bifid and asymmetrical, the right part being longer than the left part, these two parts rounded at their apex; the scaphium is very characteristic, highly sclerotized, carrying at its apex two lateral humps preceded by two dimples; the lateral dorsal parts of the ninth urite are narrow and long; the valvae (Fig. 3*c*) have

the costa well developed as a long and strong arm, upturned, widened at its apex, strongly sclerotized, and well colored; the valvula and the sacculus are recognizable but the sacculus is not distinct; the juxta is simple, in the shape of a lengthened plate; the penis (Fig. 3*b*) is long, with the rostral extremity widened and neatly indicated, with the distal apex upturned almost at 90 degrees and inclined toward the left side.

Genitalia ♀ : The lobes of the oviporus and the eighth urite are rather long but narrow as compared with the great development of the seventh urite. The lobes of the oviporus, as well as of the eighth urite, are abundantly clothed with bristles. The tergite of the seventh segment is strongly developed and covers the whole genitalia. The sternite of the same segment is modified; beneath the ostium bursae are found two triangular plates with their tops turned caudad: these plates lie on each side of the middle line; the ductus bursae is completely sclerotized and strongly colored; the ostium bursae is clearly marked and well visible; the bursa copulatrix is membranous and abundantly ornamented with unsclerotized folds.

New Hebrides: Mallicolo (Risbec), Tanna (Mrs. Pruvot).

Also from Solomon Islands, Fiji, and Samoa.

Genus ANUA Walker

Anua Walker, 1858, List Spec. Lepid. Ins. B.M. 15: 1788; Hampson, 1913, Cat. Lepid. Phal. B.M. 12: 425; Gaede, 1938, in Seitz 11: 472 (type *finifascia* Wlk.).

The proboscis is fully developed; the labial palpi are upturned, the second joint reaching the vertex of the head, the third joint being long and directed obliquely; the frons is smooth with a tuft of hairs; the male antennae are ciliated. The thorax has no crest. The venation is as described for the subfamily.

Anua coronata Fabricius

Fig. 4*a–c*

Noctua coronata Fabricius, Syst. Entom.: 596, 1775.

Ophiusa coronata Fabricius; Hampson, Fauna Brit. India, Moths 2: 502, 1894.

Anua coronata Fabricius; Hampson, Cat. Lepid. Phal. B. M. 12: 427, fig. 101, 1913.

Anua coronata Fabricius; Collenette, Roy. Entom. Soc. London, Trans. 76: 476, 1928.

Anua coronata Fabricius; Tams, Ins. of Samoa, Lepid. 4: 214, 1935.

Anua coronata Fabricius; Gaede, in Seitz 11: 473, pl. 49 d, 1938.

Anua coronata Fabricius; Swezey, Bernice P. Bishop Mus. Bul. 189: 171, 1946.

Anua coronata Fabricius; Viette, Pacific Science 3(4): 330, 1949.

Wingspread 72–96 mm.; length of the anterior wings 37–42 mm.

The head and the thorax are reddish brown tinted with gray; the abdomen is yellow with the anterior edge of the segments black.

The anterior wings are reddish brown irrorated with gray and black; the antemedial line is brown and is obliquely curved in the middle of the cell; the orbicular spot is small and greenish gray; at the apex of the cell the reniform spot is typically greenish gray with some small black spots; a brownish shadow is found beneath the costa; the postmedial line is brown, oblique; the submarginal line is whitish; the spaces between the ante- and postmedial lines and the subterminal line and the external margin are of a lighter shade of the background color.

The posterior wings are yellow with a middle band and a submarginal black band from the costa to the anal fold.

The underside of the wings is yellow; in the anterior wings, in the area of the inferior angle, there is an indefinite black spot; the legs are yellow with the tarsi gray.

Genitalia ♂ : The dorsal part is characterized by its asymmetry (Fig. 4*a*); the tegu-

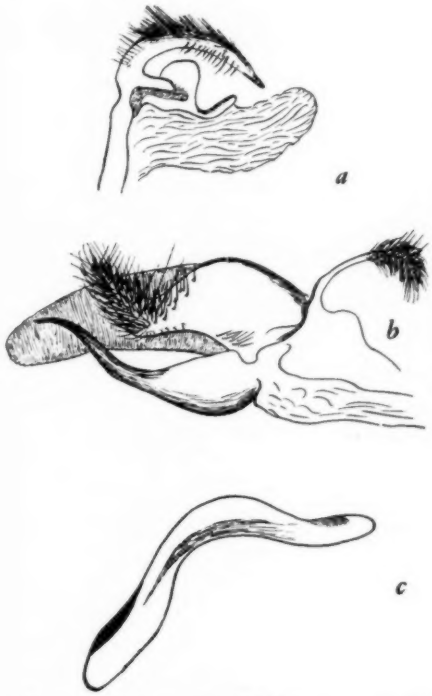

FIG. 4. *Anua coronata* Fabricius: *a*, tegumen, uncus, and anal tube; *b*, left valva; *c*, penis.

men is very narrow and the uncus is curved and clothed dorsally with bristles; on the right side, between the uncus and the anal tube, and arising from the latter, there is a vertically raised plate that is undoubtedly an excrescence of the scaphium; at the base of the uncus, toward the left, there is a kind of process directed backwards; moreover, as in most of the species still to be discussed, the valvae (Fig. 4*b*) carry, at their origin, a kind of long and narrow membranous bag abundantly clothed with bristles; there is a long costal arm, the sacculus is well developed and ends as a long, well-sclerotized and colored spur; the penis is at a right angle, speckled dorsally toward its apex (Fig. 4*c*).

Genitalia ♀ : Resemble the genitalia of *Lagoptera miniacea* Feld., showing a large seventh segment and two lateral, triangular plates at the middle line beneath the ostium bursae; however, it is distinguished from *L. miniacea* by a larger development of the eighth urite and by the ductus bursae which has first a sclerotized part, then a separate less sclerotized area, and finally an area in which there are some sclerotized longitudinal lines; the bursa copulatrix is membranous.

Hampson (1913) cites the following aberrations described as species by the old authors, because of the coloration of the reniform spot:

magica Hübner, Zutr. Exot. Schmett. 3: 32, figs. 535 and 536, 1827. The reniform spot is entirely black.

leonina Fabricius, Syst. Entom.: 596, 1775. The reniform spot is entirely green-gray.

ancilla Fabricius, Entom. Syst. 3(2): 17, 1794. The reniform spot is absent.

New Caledonia: Nouméa (coll. Fleutiaux).

New Hebrides: Pentecôte Island (Mrs. Pruvot).

This species has a geographical distribution that extends from India to the Society Islands.

Genus ACHAEA Hübner

Achaea Hübner, 1827, Verz. bekann. Schmett., p. 269; Hampson, 1913, Cat. Lepid. Phal. B. M. 12: 496; Gaede, 1938, in Seitz 11: 479 (type *janata* L.).

The proboscis is fully developed; the labial palpi are upturned, the second joint reaching almost to the vertex, the third joint being short or moderately long; in the species described here, the antennae are filiform. The thorax has no crest; the prothoracic tibiae do not possess any spines, but the meso- and metathoracic tibiae do have them. The first segments of the abdomen bear tufts of hairs dorsally.

The genus contains numerous species occurring chiefly in the Ethiopian area, southern and southeastern Asia, and as far east as the

Marquesas archipelago. Two species are of interest here.

Key to the species

1. The third joint of the labial palpi is almost as long as the second joint; the posterior wings have two medial white spots . . . . . **serva**
   The third joint of the labial palpi is very short; the posterior wings present a medial white band . . . . . **janata**

Achaea serva Fabricius
Fig. 5*a–d*

Noctua serva Fabricius, Syst. Entom., p. 593, 1775.
Ophiusa serva Fabricius; Hampson, Fauna Brit. India, Moths 2: 495, 1894.
Achaea serva Fabricius; Hampson, Cat. Lepid. Phal. B.M. 12: 521, fig. 123, 1913.
Achaea serva Fabricius; Tams, Ins. of Samoa, Lepid. 4: 216, 1935.
Achaea serva Fabricius; Gaede, in Seitz 11: 480, pl. 52 d, 1938.
Achaea serva Fabricius; Swezey, Bernice P. Bishop Mus., Bul. 186: 172, 1946.
Achaea serva Fabricius; Viette, Pacific Science 3(4): 330, 1949.

Wingspread 62–80 mm.; length of the anterior wings 34–41 mm.

The head and the thorax are reddish brown and the abdomen brown-gray.

The anterior wings are red-brown, more or less dark; the antemedial line is dark, oblique, waved; a black spot is in the middle of the medial cell; the reniform spot is small, occasionally even indistinct, and sometimes only a blackish shadow can be seen in its place; the medial line is slightly sinuous, curved exteriorly on a level with the medial cell; the postmedial line is dark and sinuous; the marginal area is of the background color, but darker, with an indication of a subterminal line; sometimes there is a series of black spots along the external margin.

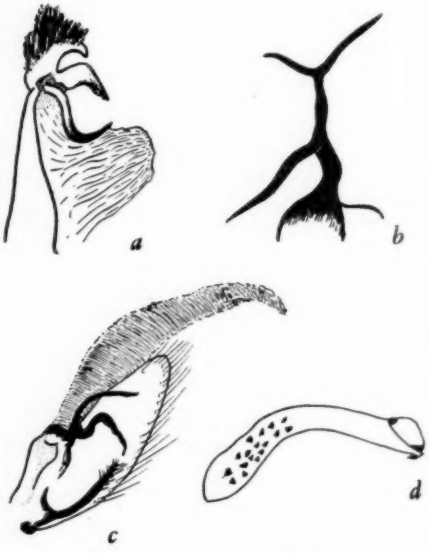

FIG. 5. *Achaea serva* Fabricius: *a*, tegumen, *b*, asymmetrical formation of the costal part of the left valva; *c*, right valva; *d*, penis.

The posterior wings are black with a purplish blue reflection and on each wing there are five white spots, two in the middle, and three near the margin, at the extremity of costa, of M_2, and between Cu_{1b} and A 1.

The underside of the four wings is grayish white, irrorated with black scales; in the anterior wings, there are a white spot on the discocellular veins and a large black spot in the area of the inferior angle of the wing; in the posterior wings there is a brown submarginal band which becomes black toward the anal angle.

Genitalia ♂: The tegumen is very narrow and carries an important excrescence raised vertically, curved at its end, and clothed dorsally with strong bristles (Fig. 5*a*); the lateral parts of the ninth urite are progressively narrowed dorsally; the uncus is curved ventrally at its apex; the anal tube carries a very well-developed scaphium; at their base the valvae (Fig. 5*c*) have a long bag abundantly clothed with bristles, and they are

simple, oval, with a distinct sacculus; in the proximal part of the dorsal area they have an asymmetrical formation that arises from the costa (Fig. 5*b* and *c*); between this part and the sacculus is the valvula; the penis is curved, with a great many cornuti and a point at its apex on the ventral side (Fig. 5*d*).

Genitalia ♀ : The lobes of the oviporus are small, lengthened, and clothed with bristles, as is the eighth urite which is well developed; the anterior and posterior apophyses are present; the tergite of the seventh segment is very well developed; the ostium bursae is in the middle of a sclerotized area which extends caudad in the shape of a band that joins the eighth segment; beneath the ostium bursae is a plate that works like a clapper and is homologous with the two fused triangular plates described in the two previous species; this plate has a medial notch in the shape of a V on its caudal edge; the first part of the ductus bursae is sclerotized, becoming less heavily sclerotized; the bursa copulatrix is, in part, also lightly sclerotized.

New Caledonia (Marie, Quod): Mont Mou (Quod), Western Coast (Risbec).

Loyalty Islands: Lifu (Marshall).

New Hebrides: Vaté (Turner).

Also in Samoa.

Achaea janata Linné

Fig. 6*a–c*

Geometra janata Linné, Syst. Natur., ed. 10, p. 527, 1758.

Achaea janata Linné; Rebel, Hamb. Wiss. Anstalt, Jahrb., 2 Beiheft, 32: 128 and 149, 1915.

Achaea janata Linné; Collenette, Roy. Entom. Soc. London, Trans. 76: 477, 1928.

Achaea janata Linné; Tams, Ins. of Samoa, Lepid. 4: 216, 1935.

Achaea janata Linné; Swezey, Bernice P. Bishop Mus. Bul. 186: 171, 1946.

Achaea janata Linné; Viette, Pacific Science 3(4): 331, 1949.

Noctua melicerta Drury, Ill. Exot. Ins. 1: 42, pl. 23, fig. 1, 1770.

Ophiusa melicerta Drury; Hampson, Fauna Brit. India, Moths 2: 494, 1894.

Achaea melicerta Drury; Hampson, Cat. Lepid. Phal. B.M. 12: 536, fig. 124, 1913.

Achaea melicerta Drury; Gaede, in Seitz 11: 480, pl. 52 f, 1938.

Achaea pentasema Prout; Ann. and Mag. Nat. Hist. IX, 3: 181, 1919.

Achaea pentasema Prout; Viette, Pacific Science 3(4): 331, 1949.

Wingspread 52–60 mm.; length of the anterior wings 27–32 mm.

The head and the thorax are gray, occasionally mixed with reddish brown; the abdomen is gray.

The anterior wings typically have a grayish brown background color with a basal black streak well indicated only in the costal half, and an antemedial black line, waved, oblique; two black spots are on a level with the discocellular veins; then comes a blackish brown space, between the postmedial and submarginal lines; from the costa a dark line extends toward the apex; along the external margin there is a series of black spots. This typical coloration is very variable; the background color can be darker, with the brownish black tracings sometimes being less evident, sometimes lacking completely.

The posterior wings are blackish brown with a purplish blue reflection; the base of the wings is lighter; a medial white band and three marginal spots are placed at the apex of the costa, on a level with M_2 and at the anal angle.

Genitalia ♂ : As in *A. serva* the tegumen has a dorsal excrescence which is densely clothed with bristles (Fig. 6*a*) and becomes rostral distad of the excrescence; at the apex a sclerotized blade emerges from the bristles; the uncus has a normal shape terminating in a point; there is a well-developed scaphium covered at the extremity with fine hooks; the

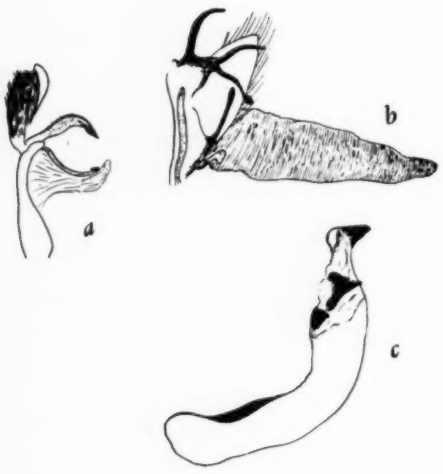

FIG. 6. *Achaea janata* Linné: *a*, tegumen, uncus, and anal tube; *b*, right valva; *c*, penis.

lateral parts of the ninth segment are narrow; the valvae (Fig. 6*b*) have a spur-shaped well-defined sacculus; the superior or costal part of the valvae is reduced here to an area carrying three long, strongly sclerotized, well-colored processes; between them can be seen a simple valvula; at the base of the valvae there is a long, membranous bag, covered with many bristles as there is in *A. serva*; the penis (Fig. 6*c*) is dorsally curved, asymmetrical, pointed, and well colored at its apex, and has a vesica with many thick cornuti.

Genitalia ♀: Similar to *A. serva* but distinguished by the shape of the sclerotized area above the ostium bursae, which is here fully developed, extends full width to the eighth urite and is inflected on the edges, forming a sort of pocket at the depth of which the ostium bursae opens; the clapper, placed underneath the copulatory opening, is almost square, with the medial notch of the caudal edge rounder; the bursa copulatrix is less sclerotized.

New Caledonia (Marie): Nouméa (Quod, Risbec, Catala).

New Hebrides: Vaté, Port Vila (Kowalsky).

This species extends from the Persian Gulf to the Marquesas Islands.

Genus PARALLELIA Hübner

Parallelia Hübner, 1827, Verz. bekann. Schmett., p. 269; Hampson, 1913, Cat. Lepid. Phal. B.M. 12: 551; Gaede, 1938, in Seitz 11: 481 (type, *bistriaris* Hb.).

The proboscis is fully developed; the labial palpi are upturned; the second joint is on a level with the vertex and lightly scaled; the frons is smooth with a tuft of hairs above; the male antennae are ciliated; the pro- and metathoracic tibiae are generally without spines.

Key to the species

1. Anterior wings with the costa showing a light lobe before its middle . **redunca**
   Anterior wings with the costa not showing a similar lobe 2
2. Anterior wings with the postmedial line toothed beneath M_1 . . . . . **prisca**
   Anterior wings with the postmedial line not toothed beneath M_1 . . . . **joviana**

Parallelia redunca Swinhoe
Fig. 7*a–d*

Ophiusa redunca Swinhoe, Cat. Lepid. Heter. Mus. Oxon. 2: 141, 1900.
Parallelia redunca Swinhoe; Hampson, Cat. Lepid. Phal. B.M. 12: 553, fig. 131, 1913.
Parallelia redunca Swinhoe; Gaede, in Seitz 11: 481, pl. 53 a, 1938.
Parallelia redunca Swinhoe; Viette, Pacific Science 3(4): 331, 1949.

Wingspread 61–64 mm.; length of the anterior wings 28–29 mm.

The head and thorax are reddish brown, the tegulae have a whitish apex; the legs are clothed with gray hairs which are yellow at their origin.

The anterior wings have a background

color of reddish brown, more or less tinged with purplish gray, chiefly in the costal half. There are three transverse lines; the antemedial is the most distinct, and is dark, edged laterally by lighter color; there is an indication of a dark medial line; the postmedial line is formed, as is the antemedial, but at first it is perpendicular to the costa, then is deeply curved inward; the costal part, which is darker in color, does not pass this line; the space exterior to the postmedial line is lighter in color, with, in the male, a black spot on a level with M_1; there is also a marginal series of little black points; the cilia are dark.

The posterior wings are blackish gray with an indication of gray bands, in the middle and at the anal angle, both perpendicular to the abdominal edge.

The underside is gray-white with the postmedial line only slightly indicated.

Genitalia ♂: It is narrow and high; the lateral parts of the ninth urite are narrow dorsally; the uncus (Fig. 7*a*) is strongly modified, consisting of plates raised vertically, abundantly clothed with bristles on the rostral side and carrying a strong dorsal tooth on the caudal side; the scaphium is well constituted; the vinculum is reduced; the valvae (Fig. 7*b*) are rather complex, having a well-defined sacculus; there is a simple valvula, which is slightly pointed and turned at its apex; the costal part is strongly denticulated with a sharp, sclerotized and well-colored apex; laterally, at the basis of the valvae, is a membranous bag clothed with bristles; the penis (Fig. 7*c*) is strongly curved dorsally in its rostral part, its caudal part is very much sclerotized; there are no cornuti.

Genitalia ♀: The lobes of the oviporus are but slightly developed as are the posterior apophyses, which are hardly sclerotized; the eighth urite shows short and clearly visible anterior apophyses, but the development of the seventh tergite is characteristic; its edges, on the ventral side, are folded, thus delimiting a kind of chamber closed by a clapper that has the shape of a lengthened trapezoid and whose caudal edge is slightly curved in the middle; the ostium bursae opens at the end of a well-colored and highly sclerotized conduit (Fig. 7*d*); the ductus bursae and the bursa copulatrix are membranous.

New Hebrides (coll. de Joannis).

Hampson (1913) cites this species from Dutch New Guinea and Queensland.

FIG. 7. *Parallelia redunca* Swinhoe: *a*, tegumen, uncus, and anal tube; *b*, right valva; *c*, penis; *d*, clapper and ostium bursae.

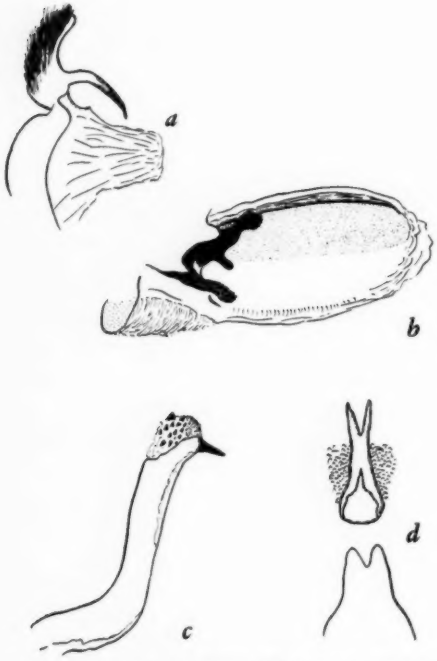

FIG. 8. *Parallelia prisca* Walker: *a*, tegumen, uncus, and anal tube; *b*, right valva; *c*, penis; *d*, clapper and ostium bursae.

Parallelia prisca Walker
Fig. 8*a–d*

Ophisma prisca Walker, List Lepid. Ins. B.M. 14: 1385, 1858.

Parallelia prisca Walker; Hampson, Cat. Lepid. Phal. B.M. 12: 558, pl. CCXIX, fig. 10, 1913.

Parallelia prisca Walker; Tams, Ins. of Samoa, Lepid. 4: 217, 1935.

Parallelia prisca Walker; Gaede, in Seitz 11: 482, pl. 53 b, 1938.

Parallelia prisca Walker; Viette, Pacific Science 3(4): 331, 1949.

Wingspread 60–65 mm.; length of the anterior wings 28–30 mm.

The head and thorax are reddish brown, the legs are gray with the tarsi yellowish gray; the abdomen is grayish brown.

The anterior wings have a dark reddish brown background color; the subbasal line, which is clearly indicated in the costal half, is red-brown, defined on each side by reddish ochre; the oblique and sinuous antemedial line is red-brown defined on each side by reddish ochre; there is a white spot, more or less marked, in the middle of the medial cell; the reniform spot is small, defined by a dark edging; there is a series of dark red-brown lines curved outwardly but becoming perpendicular at the inferior edge of the wing; these lines grow dimmer and dimmer in the marginal area till they are almost unicolored dark reddish brown; the external margin of the wing is a purplish pale gray; in the apical area there is an oblique white streak partly edging a chocolate brown apical spot.

The posterior wings are dark gray with purplish white-gray medial and marginal bands; none of these bands reaches the costa.

The underside of the wings is more or less dark gray with slightly purplish reflections at the basis of the posterior wings and is irrorated with black scales.

Genitalia ♂: The dorsal parts of the ninth urite are slightly incurved; between the much reduced tegumen and the typical uncus is a strong plate (Fig. 8*a*) vertically raised and abundantly clothed with bristles in its rostral part; the valvae (Fig. 8*b*) are oval, and differ from those of the other two species in having a kind of clavus toward the base and, in the costal half, a sclerotized modified formation; the penis (Fig. 8*c*) is highly upturned, with a strong point at its apex, and shows many cornuti.

Genitalia ♀: Similar to the female genitalia of *P. redunca* but can be distinguished easily by the shape of the process on the conduit which is contiguous with the ostium bursae, and by the shape of the clapper whose caudal edge is deeply notched in its middle (Fig. 8*d*).

New Hebrides (coll. de Joannis).

Loyalty Islands (coll. Mus. Hist. Nat. Paris).

Also from Samoa, Tonga, and Fiji.

Parallelia joviana Stoll
Fig. 9*a–d*

Noctua joviana Stoll, Pap. Exot. 4: 237, pl. 399, fig. B, 1782.
Ophiusa joviana Stoll; Hampson, Fauna Brit. India, Moths 2: 499, 1894.
Parallelia joviana Stoll; Hampson, Cat. Lepid. Phal. B.M. 12: 571, fig. 132, 1913.
Parallelia joviana Stoll; Gaede, in Seitz 11: 485, pl. 53 f, 1938.
Parallelia joviana Stoll; Viette, Pacific Science 3(4): 331, 1949.

Wingspread 43–46 mm.; length of the anterior wings 20–22 mm.

The head and thorax are purple-gray, more or less dark, while the abdomen is gray; the labial palpi and the underside of the body and the legs are fawn-gray.

The anterior wings have a brownish gray background color; in the proximal third of the wing can be seen the red-brown subbasal line, laterally edged by ochre-brown; this subbasal line does not extend beyond the costal half of the wing and there is an antemedial line, formed in the same manner, slightly curved toward the inside; the postmedial line is whitish gray, at first almost perpendicular to the costa, then becoming undulate. Inward of this postmedial line is a large dark brown area, bordered by a semicircular line, edged with a whitish gray space; the space between the postmedial line and the external margin is grayish brown with a dark brown spot at the apex, preceded, near the costa, by purplish gray. There is a marginal series of black dots.

The posterior wings are blackish gray, lighter basally and with the margin purplish gray in the abdomen angle area.

The underside is ochre-brown irrorated with darker spots.

Genitalia ♂: The tegumen is very narrow and almost indistinct, with a long, strongly downcurved, and well-developed saccus (Fig. 9*a*); the uncus has a lateral tuft of bristles at its base; there is a well-developed scaphium; the vinculum is reduced; the valvae (Fig. 9*b*) are modified; the costal part of the valva is changed into a long widened arm indented at its apex; the sacculus is long, filiform, bristled at its apex; the valvula is fully developed, clothed with bristles on its edges; lateral to the valva can be seen a long membranous bag, abundantly clothed with

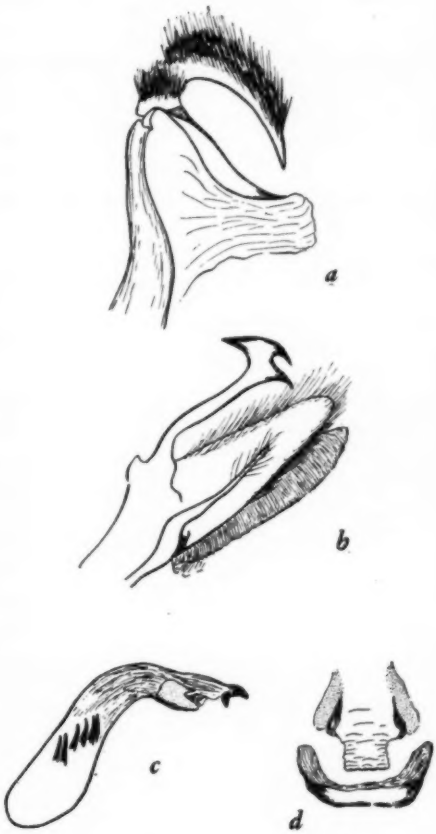

FIG. 9. *Parallelia joviana* Stoll: *a*, tegumen, uncus, and anal tube; *b*, right valva; *c*, penis; *d*, clapper and ostium bursae.

bristles; the penis is curved at a right angle, is asymmetrical, and has cornuti (Fig. 9*c*).

Genitalia ♀: The female genitalia are distinguished from those of the other species by the shape of the ostium bursae and of the clapper; the clapper is thick, showing folds of stronger sclerotization, and is semicircular (Fig. 9*d*).

Loyalty Islands: Lifu (Hampson, 1913).

New Hebrides (Paris Museum, coll. de Joannis).

The species extends from India to the New Hebrides.

Genus GRAMMODES Guénée

Grammodes Guénée, 1852, Spec. Gén. Lépid., Noct. 3: 275; Hampson, 1913, Cat. Lepid. Phal. B.M. 13: 13; Gaede, 1938, in Seitz 11: 489 (type *geometrica* F.).

The proboscis is fully developed, the labial palpi are upturned; the second joint reaches the vertex of the head and is slightly scaly; the third joint is small and oblique; the frons is smooth with tufts of hairs above; the male antennae are ciliated. The thorax has no crest, the prothoracic tibiae are not spined, but the metathoracic tibiae have spines at their base. The abdomen is clothed with scales, and is without a crest. The anterior wings have a rounded apex and the medial cell of the posterior wings reaches a third of the length of the wings.

Only one species is known from this area.

Grammodes oculicola Walker

Fig. 10*a–d*

Grammodes oculicola Walker, List Spec. Lepid. Ins. B.M. 14: 1446, 1858.

Grammodes oculicola Walker; Hampson, Cat. Lepid. Phal. B.M. 13: 15, 1913.

Grammodes oculicola Walker; Collenette, Roy. Entom. Soc. London, Trans. 76: 477, 1928.

Grammodes oculicola Walker; Gaede, in Seitz 11: 489, pl. 54 e, 1938.

Grammodes oculicola Walker; Viette, Pacific Science 3(4): 331, 1949.

Wingspread 34–42 mm.; length of the anterior wings 16–19 mm.

The head, labial palpi, thorax, and abdomen are gray, the labial palpi and the abdomen being lighter in color.

The anterior wings have a brown background color with two rather wide creamy-white oblique bands; the more basal band starts from the basal third of the costa and reaches the middle of the inferior edge of the wing; the second band starts from the distal third of the costa; it is parallel to the first band till Cu_{1a} is reached, then it is suddenly narrowed, changes direction and reaches the inferior margin of the wing at a point where it almost touches the first band; in the inferior angle there is a black spot margined anteriorly and posteriorly by a fine bluish white streak; along the external margin there is a more or less well-defined ochre-brown band; the cilia are gray in the proximal half and white in the distal half.

The posterior wings are blackish gray with a rather wide medial white band perpendicular to the costa, that is turned at its apex and does not reach the anal angle; the cilia are white except on a level with the costa and M_3, where they are black; they become gray in the area of the anal angle.

The underside of the wings is blackish gray, white basally, and with well-marked white tracings.

Genitalia ♂: The tegumen is indistinct, dorsally there is an uncus (Fig. 10*a*) which has a tuft of long, vertically raised bristles laterally, and a similar tuft dorsally and ventrally; the scaphium is well distinguished and sclerotized; a little above the articulation of the valvae, from the dorsal part of the ninth urite, two lateral extensions arise; the valvae (Fig. 10*b*), although distinct, are simple; the costa and the sacculus are well developed, and have the shape of long, highly sclero-

FIG. 10. *Grammodes oculicola* Walker: *a*, tegumen, uncus, and anal tube (v—valva); *b*, right valva; *c*, penis; *d*, clapper.

tized, well-colored processes pointed at their apex; the valvula has its edges notched and is clothed with bristles; laterally there is a long, membranous bag abundantly clothed with scales; the penis is rather large (Fig. 10*c*), is globular at one end, and has two long cornuti.

Genitalia ♀: The lobes of the oviporus are small with rather long posterior apophyses; the eighth segment is reduced; the tergite of the seventh segment is always fully developed; the characteristic piece, the clapper, which closes the chamber where the ostium bursae opens, is formed by a long medial piece which is deeply notched at its apex and flanked at its base by two lateral parts having tufts of bristles (Fig. 10*d*).

New Caledonia: Nouméa (Paris Museum, coll. Fleutiaux).

Loyalty Islands: Lifu (coll. Paris Museum).

Genus CHALCIOPE Hübner

Chalciope Hübner, 1827, Verz. bekann. Schmett., p. 268; Hampson, 1913, Cat. Lepid. Phal. B.M. 13: 26; Gaede, 1938, in Seitz 11: 490 (type *cephise* Cr.).

The proboscis is fully developed; the labial palpi are upturned; the second joint, which reaches the vertex of the head, is lightly scaled; the third joint is short, and is clothed with raised scales beneath; the frons is smooth with tufts of hairs above; the male antennae are ciliated. The thorax is without crest, the meso- and metathoracic tibiae have long hairs on their inner side and are spined, the prothoracic tibiae are not spined. The abdomen is smooth without crest. The anterior wings have a slightly projected apex. In the males the basal area of the underside of the wings is clothed with specialized hairs.

Chalciope cephise Cramer

Fig. 11*a–c*

Noctua cephise Cramer, Pap. Exot. 3: 59, pl. 227, fig. C, 1779.

Trigonodes cephise Cramer; Hampson, Fauna Brit. India, Moths 2: 528, 1894.

Chalciope cephise Cramer; Hampson, Cat. Lepid. Phal. B.M. 13: 30, fig. 6, 1913.

Chalciope cephise Cramer; Tams, Ins. of Samoa, Lepid. 4: 217, 1935.

Chalciope cephise Cramer; Gaede, in Seitz 11: 490, pl. 54 f, 1938.

Chalciope cephise Cramer; Viette, Pacific Science 3(4): 331, 1949.

Wingspread 53–61 mm.; length of the anterior wings 26–29 mm.

The head, the thorax, and the abdomen are more or less light ochre-gray; the labial palpi and the frons are darker; the legs are ochre.

The anterior wings are dark brown with a wide costal, marginal band and, at the inferior edge, are cream-white irrorated with

black scales; the dark brown space thus defined is divided by a wide, oblique band extending from the middle of the costa to the external inferior angle; there is a submarginal line of black spots in the light marginal space.

The posterior wings are blackish gray with a yellowish white basal spot and a medial space both poorly defined; the area of the anal angle is also yellowish white but somewhat grayer.

The underside of the wings is ochre irrorated with black scales. In the anterior wings there is a black spot in the distal half of the wing preceded by a yellowish white one.

Genitalia ♂ : The tegumen is indistinct, but there is a well-developed uncus (Fig. 11*a*) which is acute apically and bears a long tuft of bristles both dorsally and ventrally; the scaphium is present but is almost perpendicular to the uncus; the anal tube is short and rather low with regard to the uncus; the valvae (Fig. 11*b*) show little development of the costal part and sacculus; the apex is rounded, clothed with long, strong bristles; the internal side of the valva has a long, narrow process, well sclerotized and colored at its end. (Should it be considered as a harpe?) The juxta is highly developed and, laterally to the penis, shows two triangular parts clothed with small prickers; the penis is curved at its apex and is speckled (Fig. 11*c*).

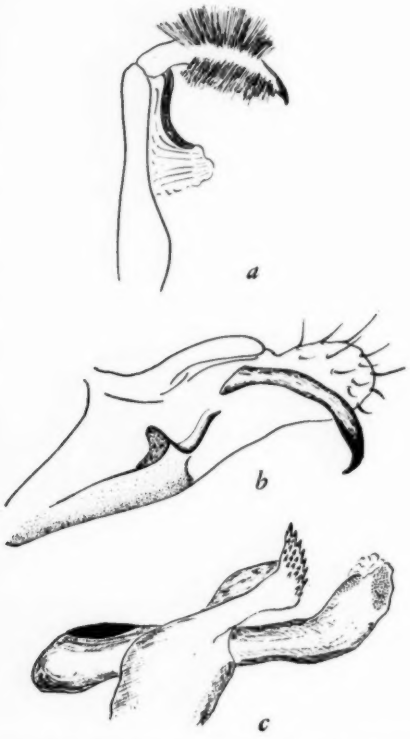

FIG. 11. *Chalciope cephise* Cramer: *a*, tegumen, uncus, and anal tube; *b*, right valva; *c*, penis and juxta.

New Hebrides: Mallicolo (Risbec).

The species is also found in Samoa.

Genus MOCIS Hübner

Mocis Hübner, 1827, Verz. bekann. Schmett., p. 267; Hampson, 1913, Cat. Lepid. Phal. B.M. 13: 76; Gaede, 1938, in Seitz 11: 493 (type *undata* F.).

The proboscis is fully developed; the labial palpi are upturned; the second joint reaches the vertex of the head and is slightly scaly; the third joint is short, oblique; the frons is smooth; the male antennae are ciliated. The thorax, without crest, is clothed with scales; the prothoracic tibiae are not spined; the metathoracic tibiae are spined. The abdomen is clothed with scales, without crest. In the anterior wings, the apex is slightly projected; the venation is similar to that of the species last described.

Key to the species

1. Anterior wings with two parallel, rather wide, transverse bands . **trifasciata**
   Anterior wings with an oblique transverse band, narrower, starting from the apex . . . . . **frugalis**

Mocis frugalis Fabricius

Fig. 12*a–c*

Noctua frugalis Fabricius, Syst. Entom., p. 601, 1775.
Remigia frugalis Fabricius; Hampson, Fauna Brit. India, Moths 2: 527, 1894.
Mocis frugalis Fabricius; Hampson, Cat. Lepid. Phal. B. M. 13: 87, fig. 23, 1913.
Mocis frugalis Fabricius; Collenette, Roy. Entom. Soc. London, Trans. 76: 478, 1928.
Mocis frugalis Fabricius; Tams, Ins. of Samoa, Lepid. 4: 218, 1935.
Mocis frugalis Fabricius; Gaede, in Seitz 11: 493, 1938.
Mocis frugalis Fabricius; Viette, Pacific Science 3(4): 331, 1949.

Wingspread 33–36 mm.; length of the anterior wings 18–19 mm.

The head, thorax, and abdomen are gray, the head and thorax being darker than the abdomen; the legs are gray mixed with ochre.

The anterior wings have a background color of dark gray mixed with black scales; the costa and the apex are a darker, blackish gray. The coloration of the species is rather variable; typically there is: a reniform spot slightly marked on the discocellular veins; a variable, elongate, medial, ochre-brown spot above the anal vein; a transverse, oblique, ochre-brown band starting from the apex and reaching the distal third of the inferior margin; within this band is a fine black line edged with cream-white; there is a submarginal series of black spots, each spot being on a vein, and these spots are bounded by a fine ochre-brown line; the external margin is ornamented with a fine black line, and a black spot is found at the proximal third of the inferior edge.

The posterior wings are blackish gray, with the base and a slightly medial band lighter in color.

The underside is blackish gray, with the marginal parts darker in color.

Genitalia ♂: The tegumen is very small, almost indistinct; the uncus (Fig. 12*a*) is typical; there is a scaphium; the lateral parts of the ninth urite are narrow; the valvae (Fig. 12*b*) are complicated, showing a strong process dorsally, a series of teeth ventrally, and a kind of long, colored, and strongly sclerotized spur medially; the penis is curved; the juxta is laterally lengthened (Fig. 12*c*) by two formations that meet dorsad of the penis; the part thus formed is very sharp and bears a number of sclerotized teeth.

Genitalia ♀: The lobes of the oviporus and the parts of the eighth segment are normal with anterior and posterior apophyses; the tergite of the seventh segment is always well developed, but here the lateral edges of the ventral side fuse with the part called the clapper in the preceding species, and thus only the apex remains free; hence the ostium bursae opens at the bottom of a completely enclosed chamber; the ductus bursae is first sclerotized, then membranous, then sclero-

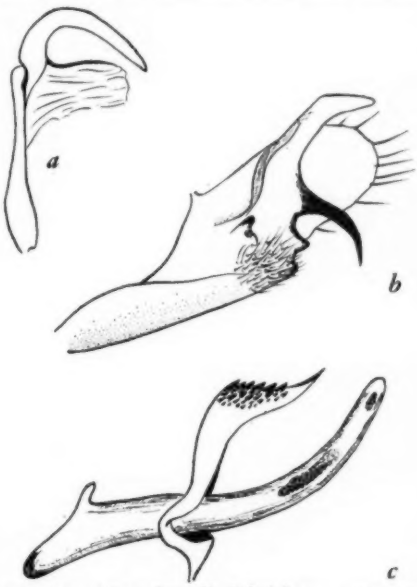

FIG. 12. *Mocis frugalis* Fabricius: *a*, tegumen, uncus, and anal tube; *b*, right valva; *c*, penis and juxta.

tized again; the bursa copulatrix has a slightly sclerotized part and a membranous part.

New Caledonia (Marie): Canala (Delacour), Nouméa, Voh (Catala).

This species has a wide geographical range extending over the Ethiopian region, the Indo-Australian area, and the Pacific islands (Carolines, Marshall, Gilbert, Ellice, Fiji, Samoa) to the Marquesas Islands and the Tuamotu Archipelago.

The specimens from New Hebrides and the Loyalty Islands, indicated in my Catalogue (1949), actually belong to the next species.

Mocis trifasciata Stephens

Fig. 13*a–c*

Catephia trifasciata Stephens, Ill. Brit. Entom. Haust. 3: 128, 1829.
Mocis trifasciata Stephens; Hampson, Cat. Lepid. Phal. B.M. 13: 93, pl. CCXXIII, fig. 23, 1913.
Mocis trifasciata Stephens; Collenette, Roy. Entom. Soc. London, Trans. 76: 478, 1928.
Mocis trifasciata Stephens; Tams, Ins. of Samoa, Lepid. 4: 218, 1935.
Mocis trifasciata Stephens; Gaede, in Seitz 11: 493, pl. 55 c, 1938.
Mocis trifasciata Stephens; Viette, Pacific Science 3(4): 331, 1949.

Wingspread 45–48 mm.; length of the anterior wings 21–23 mm.

The head and thorax are brownish gray, the abdomen is gray; the legs are gray mixed with ochre-brown.

The anterior wings are gray irrorated with black scales and have a slight bluish reflection. Typically, a rather wide transverse band can be seen, which is ochre-brown at the basal third of the wing; interiorly it has a cream line; toward the exterior it is poorly defined and mixes with the background color; another ochre-brown transverse band is at the distal third of the wing; this band is wider at the costa than at the inferior edge, and it too is very badly defined, having lighter and darker parts; exterior to it is a line of black spots; the marginal band is a little darker than the background color; the margin is a thin black line.

The posterior wings are ochre-brown-gray, with the abdominal margin, a medial band, and some parts along the external margin creamy white.

The underside is ochre with darker distal parts.

Genitalia ♂: The lateral dorsal parts of the ninth urite are narrow; the tegumen is indistinct and the uncus is typical with a small beak at the apex (Fig. 13*a*); the scaphium is present; the valvae (Fig. 13*b*) are subrectangular with a small lengthening at the dorsal apex; neither the costa nor the sacculus is well defined; a short process starts from the internal surface and widens

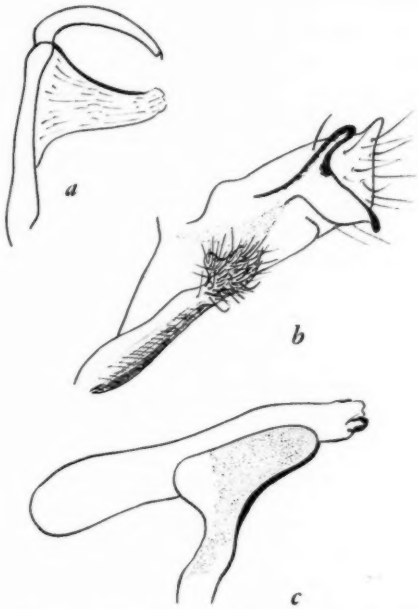

FIG. 13. *Mocis trifasciata* Stephens: *a*, tegumen, uncus, and anal tube; *b*, right valva; *c*, penis and juxta.

apically into a wide plate which carries raised extensions both dorsally and ventrally, the ventral being upturned; the penis is straight, and is carried by a juxta lengthened by two long plates, lateral to the penis (Fig. 13*c*).

Genitalia ♀: These have the same form as those of *Mocis frugalis* F., but can be distinguished by their larger anterior and posterior apophyses, and particularly by a greater specialization of the chamber where the ostium bursae opens; the lateral ventral edges of the seventh tergite come to a level with the ductus bursae upon which, beneath, is fused a lengthened part, which is curved at its caudal edge and is homologous to the part called the clapper in the other species but which here does not have the same function. Thus the ostium bursae is pushed backwards; the ductus bursae is longer, sclerotized; the bursa copulatrix is membranous.

New Caledonia: Canala (Delacour), Nouméa (Catala).

Loyalty Islands (coll. Donckier, Paris Museum).

New Hebrides: Mallicolo (Risbec); Tanna (Aubert de la Rüe); Vaté, Port Vila (Risbec).

The species extends from Ceram, New Guinea, and the Solomons to the Marquesas and the Austral Islands, including Tonga, Fiji, and Samoa.

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Upper Cretaceous Foraminifera from Japan

KIYOSHI ASANO[1]

IN THIS PAPER the discovery in Japan of smaller Foraminifera from the Upper Cretaceous strata is recorded for the first time. This contribution, in addition to its specific biostratigraphic application in Japan, has further interest by reason of its extension of the geographic range of the widely distributed Cretaceous pelagic foraminiferan, *Globotruncana.* In the north Pacific region, *Globotruncana* has heretofore been known only from the East Indian archipelago and from California.

This paper forms part of a project initiated by the Natural Resources Section, General Headquarters, Supreme Commander for the Allied Powers, for the purpose of assembling paleontologic data applicable to solution of stratigraphic problems connected with exploration for oil and coal in Japan. In the course of the geological survey connected with oil exploration in the Cretaceous areas of Hokkaido, Mr. S. Iijima of the Geological Survey of Japan collected samples in 1947 from the Upper Cretaceous rocks in the vicinity of Nakagawa-mura, Nakagawa-gun, Teshio district, Hokkaido, which, on examination, proved to contain a few specimens of *Globotruncana.* This identification was confirmed by Dr. Paul P. Goudkoff of Los Angeles, California, in a letter dated April 29, 1948. He identified *Globotruncana canaliculata* (Reuss) and species of *Gyroidina* and *Pleurostomella* in the sample. Subsequent study at Tohoku University of additional rock samples from the Upper Cretaceous of Hokkaido has revealed that although the occurrence of *Globotruncana* seems to be rare in the Absehinai area of the Teshio district of Hokkaido, *Bathysiphon, Glomospira,* and *Ammodiscoides* are commonly found.

In a well which was drilled recently to test for coal seams at Yokouchi, about 2.5 km. south of Hisanohama-machi, Futaba-gun, Fukushima Prefecture (Lat. 37° 7′ N, Long. 141° 00′ E), on the island of Honshu, the assemblage described in this paper was discovered in cores from 187 to 215 meters. The presence of Upper Cretaceous rocks in this general area was already known from the work of Tokunaga and Shimizu (1926), who recorded *Trigonia, Inoceramus,* and ammonites, indicative of Senonian age. In the core samples, from the well at Yokouchi, which consist of carbonaceous sandstones and shales, *Trigonia, Inoceramus,* and fragments of ammonites were found from 70 to 215 meters.

The Foraminifera identified from the cores between 187 and 215 meters in the Yokouchi well are:

Silicosigmoilina futabaensis, n.sp.—dominant
Globotruncana canaliculata (Reuss)—dominant
Globotruncana marginata (Reuss)—rare
Globotruncana sp.—rare
Anomalina fukushimaensis, n.sp.—dominant
Trochammina hisanohamaensis, n.sp.—few
Robulus lepidus (Reuss)—few
Robulus futabaensis, n.sp.—rare
Robulus sp.—few
Marginulina cretacea Cushman—rare
Dentalina cf. *basiplanata* Cushman—rare
Dentalina sp.—rare
Vaginulina cf. *lata* (Cornuel)—rare
Palmula suturalis (Cushman)—rare
Ellipsonodosaria sp.—rare

[1]Institute of Geology and Paleontology, Tohoku University, Sendai, Japan. Manuscript received September 7, 1949.

Both the dominant genera of this assemblage, *Globotruncana* and *Silicosigmoilina,* are recorded from Japan for the first time. Their range in Europe and North America is restricted to Upper Cretaceous formations. Several of the species recorded are widely distributed in the Upper Cretaceous strata of other regions, and four are described as new. *Silicosigmoilina futabaensis* occupies a position in the Japanese assemblage comparable to that of *S. californica* in the Upper Cretaceous of California. *Globotruncana canaliculata* is found in abundance in Europe and the Gulf Coast region of the United States, but more rarely in California.

The writer is indebted to Lt. Col. Hubert G. Schenck, chief of Natural Resources Section, General Headquarters, Supreme Commander for the Allied Powers, and professor of geology at Stanford University, California, under whose supervision and encouragement the present investigation was conducted; to Mr. Leo. W. Stach, head of the Petroleum Branch, Natural Resources Section, who was responsible for editing the manuscript; to the Hisanohama Coal Mining Co., which offered the core samples for study; to Dr. K. Hatai, Tohoku University, for advice and assistance during the investigation.

All specimens described herein are deposited in the collection of the Institute of Geology and Paleontology, Tohoku University, Sendai, Japan. Catalogue numbers of registered specimens are indicated in the text by the prefix IGPS.

Family SILICINIDAE
Genus SILICOSIGMOILINA Cushman and Church, 1929

Silicosigmoilina futabaensis Asano, n.sp.
Pl. 1, Figs. 6*a, b*; 7*a, b*

Test compressed, oval in side view, periphery subacute; chambers planispiral in earlier and sigmoidal in later stages; sutures indistinct, but fairly well marked between later chambers, not deeply depressed; wall finely arenaceous, firmly cemented with siliceous cement; aperture simple, without a tooth; white or light gray in color. Length to 0.7 mm.; breadth 0.5–0.3 mm.; thickness 0.2–0.3 mm.

Holotype: IGPS 67016.

This species is related to *Silicosigmoilina californica* Cushman and Church, a species found abundantly in the Upper Cretaceous of California, but the Japanese species has a more compressed test.

Family TROCHAMMINIDAE
Genus TROCHAMMINA Parker and Jones, 1859

Trochammina hisanohamaensis Acano, n.sp.
Pl. 1, Figs. 8*a–c*

Test much compressed, planoconvex, dorsal side flat; ventral side slightly convex, umbilicate; chambers 4 or 5 in last coil, earlier chambers indistinct; sutures indistinct except for later ones which are somewhat depressed; wall finely arenaceous, smooth. Diameter to 0.6 mm.

Holotype: IGPS 67017.

Trochammina texana Cushman and Waters, from the Upper Cretaceous of the Gulf Coast region, is similar to this new species, but has less depressed sutures and the chambers have no raised borders.

Family LAGENIDAE
Genus ROBULUS Montfort, 1808

Robulus futabaensis Asano, n.sp.
Pl. 1, Figs. 12*a, b*

Test closely coiled, moderately compressed, periphery acute or with a slight keel; chambers distinct, of uniform shape and increasing gradually in size, 7 or 8 in adult coil; sutures distinct, gently curved, becoming thick and raised toward umbilical area; wall smooth;

aperture radiate with a weak slit ventrally. Diameter 1.2 mm.; thickness 0.4 mm.

Holotype: IGPS 67018.

This species differs from *Robulus williamsoni* (Reuss) in the presence of distinct raised sutures near the umbo.

Robulus lepidus (Reuss)

Pl. 1, Fig. 13

Robulus lepidus Cushman and Church, 1929: 504, pl. 26, figs. 15, 16.

This species is said to be very common in the Upper Cretaceous rocks of Europe, California, and Mexico. The present specimens are identified with *Robulus lepidus* figured by Cushman and Church from the Upper Cretaceous of California.

Robulus sp.

Pl. 1, Fig. 16

There are several incomplete specimens in the collection. The figured specimen has a distinct keel and an umbonate center, but there is insufficient material for complete description.

Genus MARGINULINA d'Orbigny, 1826

Marginulina cretacea Cushman

Pl. 1, Fig. 14

Marginulina cretacea Cushman, 1937: 94, pl. 13, figs. 12–15.

This species has been recorded from many localities in the Upper Cretaceous of the Gulf Coast region of the United States, but it is rare in the present collection.

Genus DENTALINA d'Orbigny, 1826

Dentalina cf. **basiplanata** Cushman

Pl. 1, Fig. 11

Dentalina basiplanata Cushman, 1946: 68, pl. 24, figs. 1–6.

The apertural end is not preserved in any of the present specimens, although the limbate sutures are very characteristic as is shown in the figure. This species was originally described from the Corsicana Marl of Texas.

EXPLANATION OF PLATE

FIGS. 1*a–c*; 3*a–c*. *Globotruncana canaliculata* (Reuss). × 40. *a*, Dorsal aspect; *b*, peripheral aspect; *c*, ventral aspect.

FIGS. 2*a–c*; 4*a–c*. *Globotruncana marginata* (Reuss). × 40. *a*, Dorsal aspect; *b*, peripheral aspect; *c*, ventral aspect.

FIGS. 5*a–c*. *Globotruncana* sp. × 45. *a*, Dorsal aspect; *b*, peripheral aspect; *c*, ventral aspect.

FIGS. 6*a*, *b*; 7*a*, *b*. *Silicosigmoilina futabaensis* Asano, n.sp. × 40. *a*, Lateral aspect; *b*, apertural aspect. (Fig. 6, holotype. Fig. 7, paratype.)

FIGS. 8*a–c*. *Trochammina hisanobamaensis* Asano, n.sp. × 40. *a*, Ventral aspect; *b*, peripheral aspect; *c*, dorsal aspect. (Holotype.)

FIG. 9. *Palmula suturalis* (Cushman). × 35.

FIG. 10. *Dentalina* sp. × 40.

FIG. 11. *Dentalina* cf. *basiplanata* Cushman. × 40.

FIGS. 12*a*, *b*. *Robulus futabaensis* Asano, n.sp. × 40. *a*, Lateral aspect; *b*, apertural aspect. (Holotype.)

FIG. 13. *Robulus lepidus* (Reuss). × 40.

FIG. 14. *Marginulina cretacea* Cushman. × 40.

FIG. 15. *Ellipsonodosaria* sp. × 40.

FIG. 16. *Robulus* sp. × 40.

FIGS. 17*a*, *b*; 18*a–c*. *Anomalina fukushimaensis* Asano, n.sp. × 40. 17*a*, Dorsal aspect; *b*, ventral aspect. 18*a*, Ventral aspect; *b*, apertural aspect; *c*, dorsal aspect. (Fig. 17, paratype. Fig. 18, holotype.)

FIG. 19. *Vaginulina* cf. *lata* (Cornuel). × 45.

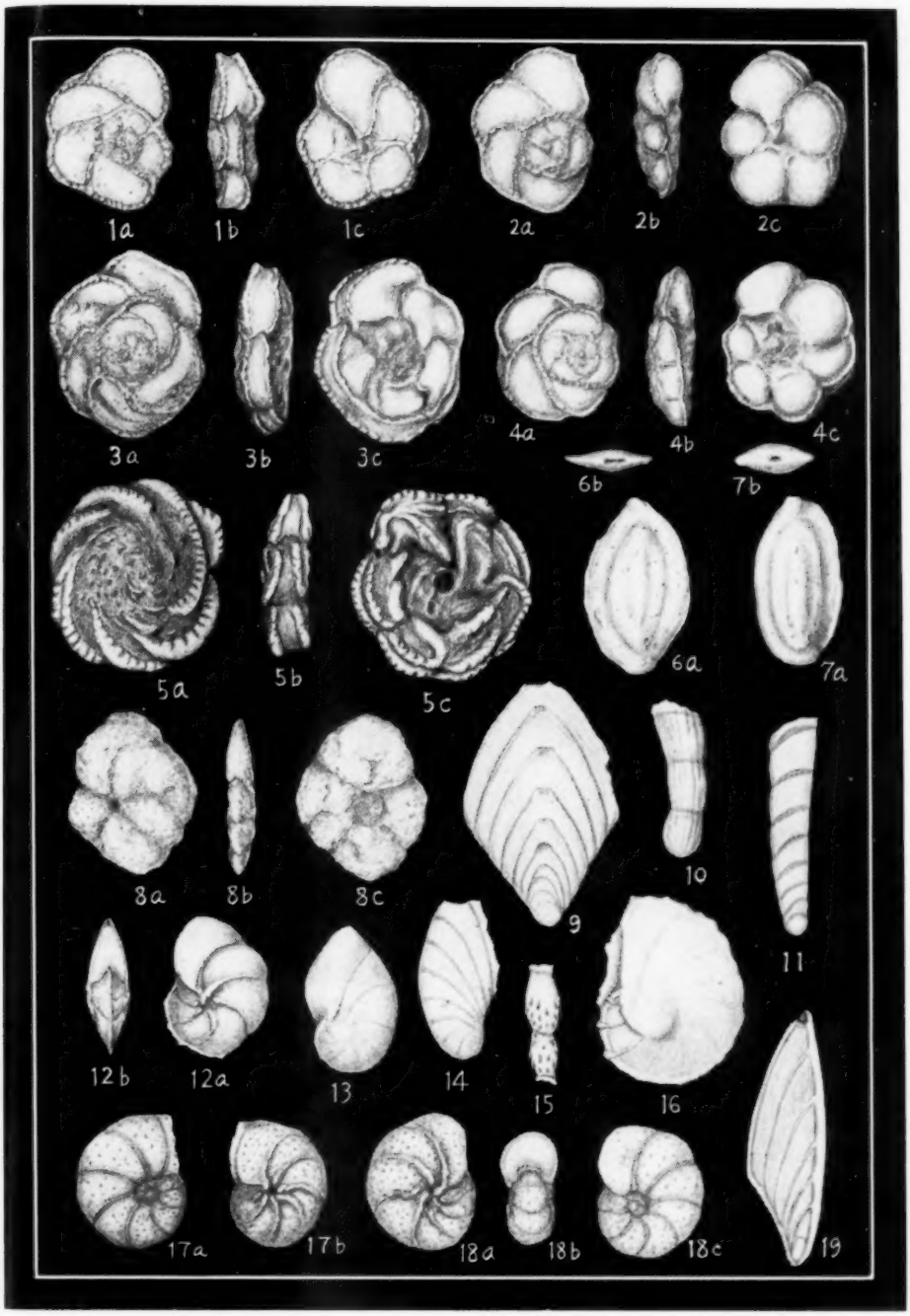

PLATE I
Species of Foraminifera from the Upper Cretaceous strata of Japan.

Dentalina sp.
Pl. 1, Fig. 10

The single fragmentary specimen in the collection does not warrant description.

Genus VAGINULINA d'Orbigny, 1826

Vaginulina cf. **lata** (Cornuel)
Pl. 1, Fig. 19

Vaginulina lata Cornuel, 1848: 252, pl. 1, figs. 34–37.

The single specimen figured is possibly the named species, but the inadequate material makes positive identification difficult.

Genus PALMULA Lea, 1833

Palmula suturalis (Cushman)
Pl. 1, Fig. 9

Flabellina suturalis Cushman, 1935: 86, pl. 13, figs. 9–18.

Palmula suturalis Loetterle, 1937: 28, pl. 3, fig. 5.

The present specimens are very similar to those figured by both Cushman and Loetterle from the Upper Cretaceous of the Gulf Coast region of the United States.

Family ELLIPSOIDINIDAE
Genus ELLIPSONODOSARIA A. Silvestri, 1900

Ellipsonodosaria sp.
Pl. 1, Fig. 15

The fragment of the spinose specimen figured resembles *Ellipsonodosaria horridens* Cushman, but the specimens are insufficient for specific identification.

Family GLOBOROTALIIDAE
Genus GLOBOTRUNCANA Cushman, 1927

Globotruncana canaliculata (Reuss)
Pl. 1, Figs. 1*a–c*, 3*a–c*

Globotruncana canaliculata Cushman, 1946: 149, pl. 61, figs. 17, 18.

The present species is abundant and very characteristic of the Upper Cretaceous of Europe and America and is found commonly in the present collection. The type of this species is from the Senonian of Europe. There is considerable variation in the shape of the chambers. The nearly parallel faces and truncate periphery are characteristic features of this species. The present specimens are similar to the typical one figured by Cushman from Bavaria.

Globotruncana marginata (Reuss)
Pl. 1, Figs. 2*a–c*, 4*a–c*

Globotruncana marginata Cushman, 1946: 150, pl. 62, figs. 1, 2.

This species is found rarely in the present collection. The dorsal and ventral sides are difficult to distinguish from *G. canaliculata*, but the presence of a single keel or the tendency to have a truncate border in the later chambers of the peripheral side is a characteristic and distinguishing feature.

Globotruncana sp.
Pl. 1, Figs. 5*a–c*

This form differs from those described above in having strongly overlapped chambers with peculiar keels. Further material is needed for specific evaluation.

Family ANOMALINIDAE
Genus ANOMALINA d'Orbigny, 1826

Anomalina fukushimaensis Asano, n.sp.
Pl. 1, Figs. 17*a, b*; 18*a–c*

Test planispiral, both sides convex, periphery broadly rounded; chambers distinct, 8 or 9 in last coil; sutures on dorsal side curved and limbate, but raised on ventral side, especially toward umbilical center; wall coarsely perforate except at umbilical region on ventral side; aperture an arched slit with a slight lip at base of last chamber. Diameter up to 0.5 mm.

Holotype: IGPS 67019.

This small species is similar to *Anomalina clementina* d'Orbigny in having raised ridges along the sutures, but is distinguished from that species by the more rounded periphery of the test.

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News Notes

The following publications of the Natural Resources Section, General Headquarters, Supreme Commander for the Allied Powers, have been received. Each report includes a list of all the reports previously published.

Reconnaissance Soil Survey of Japan (Kyushu Area). [by Robert E. O'Brien and E. J. Kohler.] Report No. 110-B. 73 pp., 12 figs., 12 tables, 10 maps.

Japanese Whaling Industry Prior to 1946. [by William M. Terry.] Report No. 126. 47 pp., 17 figs., 19 tables.

NOTES

The Occurrence of a Black Marlin, *Tetrapterus mazara*, without Spear

Although it is quite commonly believed that the spearfishes are dependent upon the use of their spears as weapons for securing food, this is not necessarily the case as is demonstrated by the following observation.

A 545-pound black marlin (*Tetrapterus mazara* Jordan and Snyder), which was without a spear, was taken recently on long-line fishing gear, in Hawaiian waters. The specimen, with others of the same species, was brought into the auction room of the Kyodo Fishing Company, Ltd., on October 24, 1949. The appearance of the specimen indicated that the spear had been lost by injury. There was no indication that the loss was at all recent although considerable scar tissue was present on the snout. Even though the fish was without a spear the specimen was equal in condition to the normal fish of the same species. This seems to disprove the belief that the spear is necessary for natural and adequate feeding. Unfortunately, length measurements of black marlin of this size are not practicable as the fish are cut in pieces to facilitate transporting to market.

According to the operators of the auction, spearfishes without spears have been observed before in the Honolulu market, although such occurrences are very rare.—*Harvey L. Moore, Section of Biology and Oceanography, Pacific Oceanic Fishery Investigations, U. S. Fish and Wildlife Service, Honolulu, Hawaii.*

Additional Records Confirming the Trans-Pacific Distribution of the Pacific Saury, *Cololabis saira* (Brevoort)[1]

During January, 1948, the senior author and Dr. O. R. Smith of the U. S. Fish and Wildlife Service collected 10 specimens of *Cololabis saira* (Brevoort) by submerged light and dip net while aboard the tuna-fishing vessel "Oregon" en route from San Diego, California, to the Hawaiian Islands. One specimen 39.0 mm. long was taken on January 4 at 28° 22′ N, 137° 12′ W. Seven specimens, 30.0, 31.5, 33.0, 34.5, 34.5, 35.0, and 36.0 mm. in length, were captured on January 6 at 25° 14′ N, 144° 41′ W. One specimen 33.0 mm. long was taken on January 7 at 23° 52′ N, 148° 41′ W. A final 48.0 mm. specimen was captured on January 9 at 23° 04′ N, 153° 19′ W. All measurements are standard length.

These additional records of occurrence of the Pacific saury substantiate Hubbs's conclusion from morphological comparison that *C. saira* and *C. brevirostris* are not distinct species (Hubbs, *Univ. Calif. Pub. Zool.* 16 (3): 157, 1916), and Schultz's note (*Copeia*, 1940 (4):270), based on his collection of specimens in the oceanic areas between San Francisco and Honolulu, indicating that *C. saira* is trans-Pacific in distribution.—*Milner B. Schaefer and John W. Reintjes, Section of Biology and Oceanography, Pacific Oceanic Fishery Investigations, U. S. Fish and Wildlife Service, Honolulu, Hawaii.*

[1]Published by permission of the U. S. Fish and Wildlife Service.